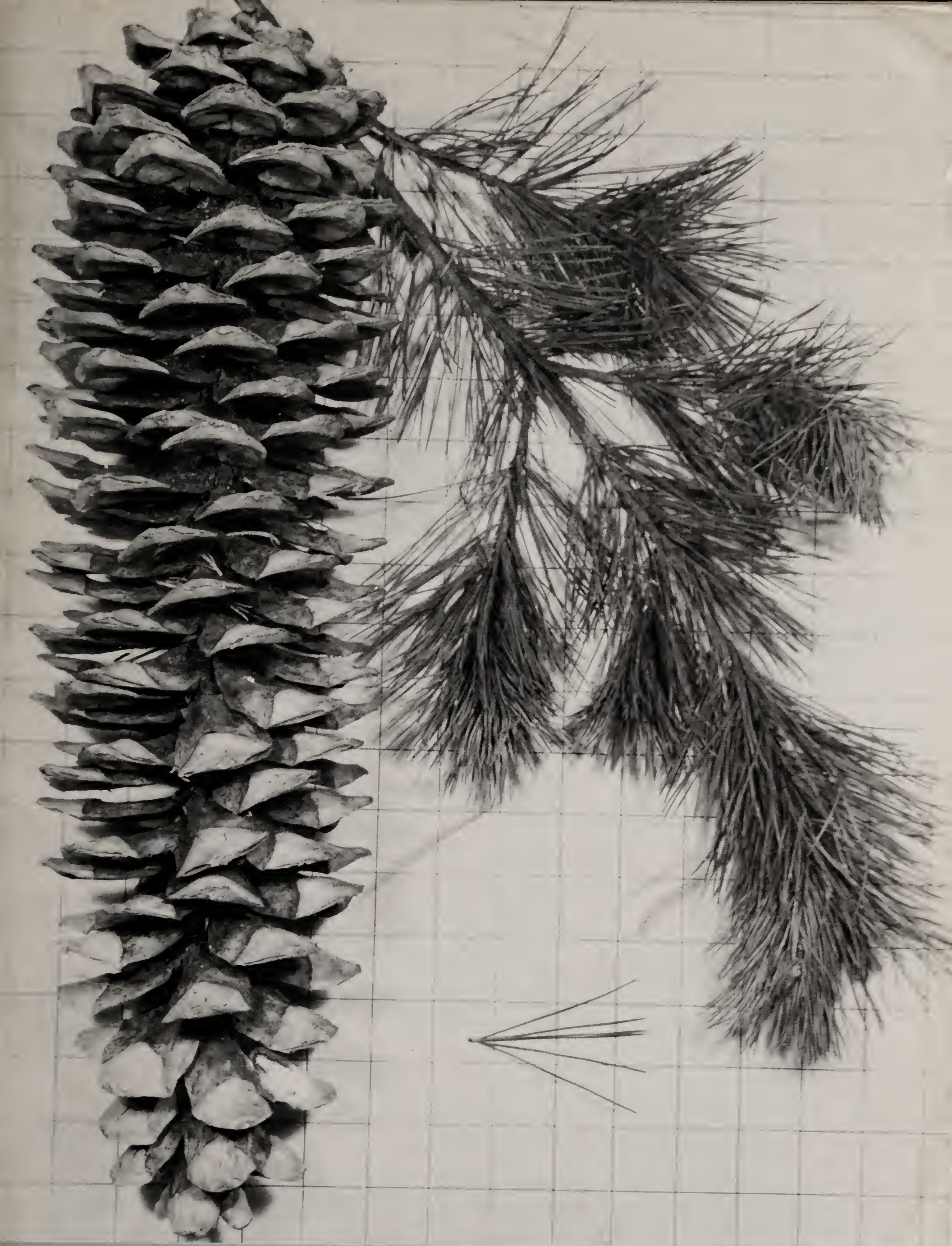

University of Washington

ARBORETUM BULLETIN

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Winter 1979, Vol. 42, No. 4

Concerning this issue . . .

The *Arboretum Bulletin* is taking its readers on a series of tours of the University of Washington campus. In this issue, Frank Brockman discusses the conifers on campus, and a map is provided for your convenience.

Have you ever wondered why certain plants in your garden fail to set fruits even though they possess both stamens and pistils? In his article, "Self-Incompatibility in Flowering Plants," Adolph Hecht presents an explanation for the chemical factors involved. Or quite the reverse, have you wondered why species integrity breaks down in so many instances in the garden—rhododendrons are a prime example—and the resulting seed set yields nothing but hybrids? Bastiaan J.D. Meeuse, to whom we are grateful for so many fascinating articles on natural history, discusses this phenomenon in "Species Hybridization in Plants." (And while you are about it, don't forget to read his delightful review of an important new book, *Bumblebee Economics* by Bernd Heinrich.) An excellent background for this pair of articles may be found in Melinda Denton's "Sexual Reproduction in Flowering Plants" *(Arboretum Bulletin*, Vol. 41, No. 1, Spring 1978).

Climate-plant relationships are an important aspect of arboretum research. Our Curator of Plant Collections, Joe Witt, has waited until all the facts were in to assess the causes and degree of damage to plants following the potentially devastating cold weather of the winter of 1978/79. His article is accompanied by short reports from other sources on damage in climates colder and warmer than that of the Arboretum.

Another aspect of this work has been the Arboretum's Ornamentals Hardiness Research Program, which is now in its fifth year. William H. Hatheway reports on this project. He collaborates with Hubertus Kohn and Joe Witt in a brief discussion of one of the more interesting findings to come out of the study, the extraordinarily hardy winter flowers of *Mahonia* 'Arthur Menzies', one of the Arboretum's more outstanding introductions in recent years.

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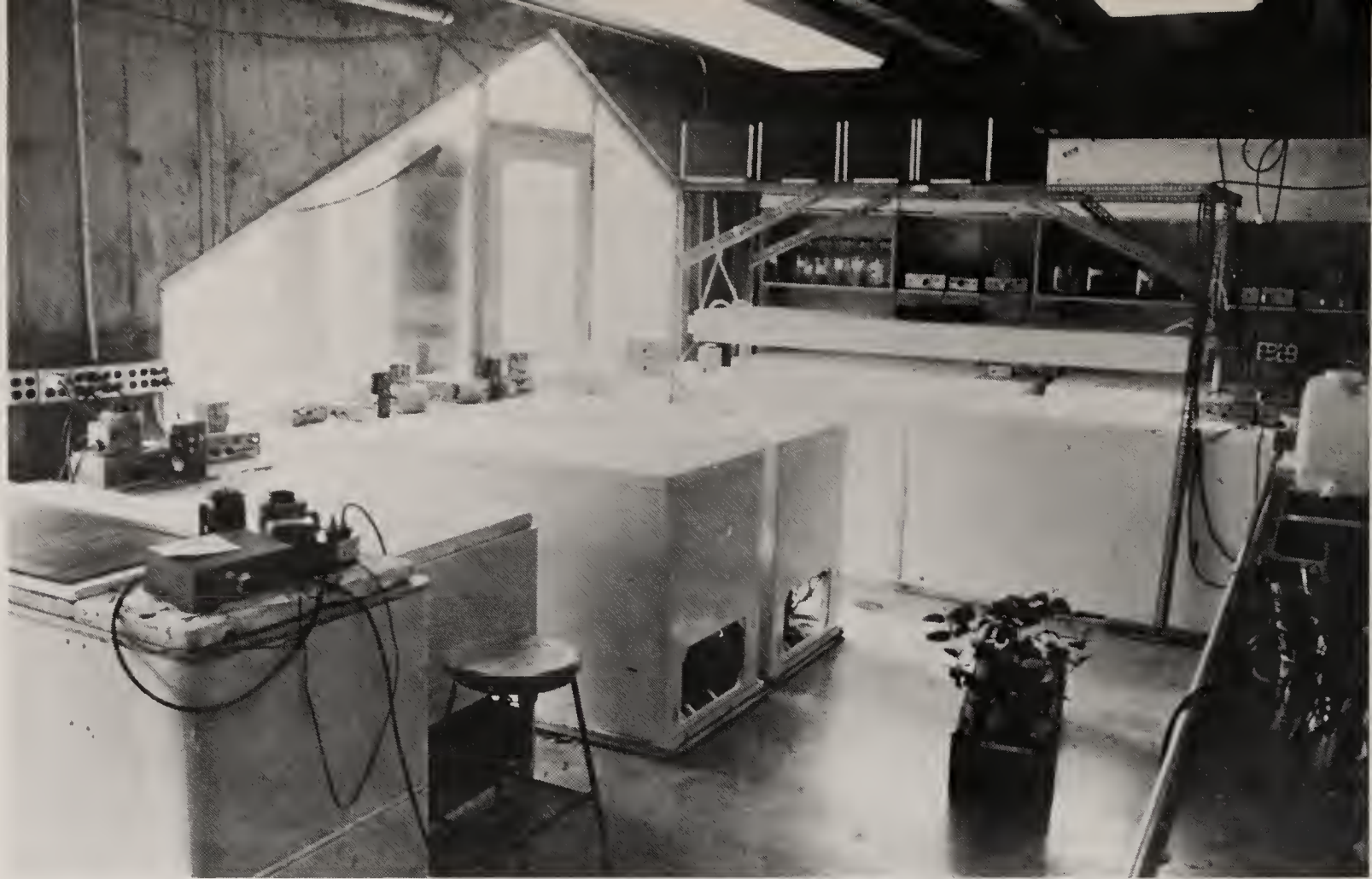
COVER
Branch and 20-inch cone of
Pinus lambertiana
See article, "University of Washington Campus Conifers."

Photo: C. Frank Brockman



Cold Resistance Laboratory, WWU. Photo: Courtesy Cold Resistance Laboratory, WWU

Status Report Ornamentals Hardiness Program August 1979

WILLIAM H. HATHEWAY

Editor's Note: The Ornamentals Hardiness[1] *Program has been co-sponsored from its inception in 1975 by the Arboretum Foundation and the University of Washingon Arboretum. Its principal investigator is Professor William H. Hatheway, UW College of Forest Resources. Laboratory testing is carried out in the Cold Resistance Laboratory of Professor Hubertus Kohn of Western Washington University in Bellingham.*

The program was introduced in the Bulletin *(38:4, Fall 1975), followed by a report of the first winter's results, "The Frost Hardiness Research Program" (40:1, 1977). We publish here the main portion of the biennial report for 1977-79. Appendices and other supplementary documents are on file in the Arboretum Office.*

The Arboretum Foundation has agreed to continue its support of the project with funds remaining from the original grant, as proposed in the following report.

PROGRESS IN 1977-1979

This section of our report covers work carried out in Professor Kohn's laboratory over the past two years. His work has been organized in five projects, details of which are presented in Appendix 1. All were designed to test the capacity of the Cold Resistance Laboratory to carry out various kinds of frost-hardiness research and screening tests. This work and the laboratory in which it was conducted were supported by the Arboretum Foundation and the Biology Department of Western Washington University. The following is a summary of some of Professor Kohn's more important results in 1977-79.

Project I. Hardening capacity of Taiwania cryptomerioides *under natural conditions*

Frost tolerance maxima for the four winters beginning in 1975/76 were −16.5, −18.0, −18.0, and −20.0 (all degrees Celsius). Noteworthy is the general consistency of these results. The slight amount of variation present is well correlated with the degree of severity of the winters (1975/76 mildest; 1978/79 most severe). This result is in line with the results of Professor Kohn and other researchers that during fall and early winter the

[1]Such terms as "hardiness", "frost hardiness", and "cold resistance" may be considered more or less interchangeable in this report. As yet, among scientists, the terminology is in a state of flux.

degree of frost resistance of hardy plants increases in direct relation to the degree of cold stress to which they have been subjected, provided that this stress increases gradually and not in a series of sudden irregular temperature changes.

Project II. Frost tolerance of plants grown in the lath house and in the open

It is the practice of the University of Washington Arboretum and several other arboreta and botanical gardens to grow relatively tender material in the protected situations afforded by lath houses. To evaluate the effectiveness of this practice, Professor Kohn compared the survival and level of frost resistance attained by plants of the same species grown in the open and in the lath house. His principal finding was that plants grown in the lath house tend to be slightly more hardy in midwinter than those grown in the open. Unfortunately, no measurements were made of air and leaf temperatures at the growth sites, so that the degree of temperature protection provided by the lath house is not known. In his report, Professor Kohn suggests that effective day lengths are somewhat shorter in the lath house than in the open, and that this difference in photoperiod rather than the differences in temperature may be important in promoting increased hardiness and hence increased survival in lath house plants. At the suggestion of Mr. Witt, these interesting experiments were carried out on several plants of *Taiwania cryptomerioides* and *Choisya ternata*. A possible application of these results, if they are confirmed over a broader range of genera, might be modification of lath house design to enhance the photoperiod effect.

Project III. Freezing resistance in Mahonia *'Arthur Menzies' flowers and leaves*

The new Arboretum hybrid *Mahonia* 'Arthur Menzies' generally flowers in late fall through midwinter. Since these flowers are physiologically active and indeed growing at a time when they are often subjected to freezing conditions, it is of considerable horticultural and theoretical interest to determine how they manage to avoid frost damage. In what way, for example, are these flowers different from those which are severely damaged by late spring frosts such as *Rhododendron mucronulatum* or *Prunus subhirtella* 'Pendula'?

Professor Kohn presents evidence that 'Arthur Menzies' avoids frost damage through the process of "supercooling". Supercooling is a well-known phenomenon in physics laboratories, where it is found that under certain conditions water and many other liquids may be cooled well below their normal freezing point without changing to the solid state. If a small ice crystal is introduced into the supercooled liquid or often if the liquid is merely shaken, it suddenly becomes solid—that is, it freezes. Supercooling is known to occur in certain fruit trees and it is believed to play an important role in extending the northern limit of distribution of certain deciduous trees in the American lake states. The mechanism by which the water in plant tissues is maintained in the liquid state when its temperature is well below the freezing point is imperfectly understood.

Project IV. Frost tolerance of 15 species in the University of Washington Arboretum

Professor Kohn determined frost tolerance curves for several additional species. Details are presented in Appendix 1. These tests are interesting for several reasons, not the least of which is the practical one that the Cold Resistance Laboratory now has the capability of testing large numbers of potential introductions to the Arboretum.

Project V. Artificial dehardening of cut samples

It is the experience of many gardeners that plants which have successfully survived difficult winters may be "nipped in the bud" by late spring frosts. The plant physiologist says that such plants have been "dehardened". By this he

***Mahonia* 'Arthur Menzies'. Photo: Joseph A. Witt**

means that the resistance to frost damage which the plants had developed during fall and early winter has been lost, usually in response to changes in the temperatures to which they have been exposed. Professor Kohn subjected cut twigs of naturally hardened plants to warm treatments for different lengths of time and then tested for frost resistance. Dehardening behavior varied considerably among the genera tested. For example, in some plants, once the process of dehardening is under way, it apparently cannot be stopped. In others it seems to be reversible.

PRESENT STATUS OF THE COLD RESISTANCE LABORATORY

I. Location

The Laboratory is located in the greenhouses and adjacent former headhouse space on the top floor of the Biology Building of Western Washington University (WWU) in Bellingham. In addition, an outdoor roof garden and four experimental plant beds at ground level have been provided by WWU.

II. Total space provided by WWU

A. Two greenhouses, each approximately 20′ × 30′, equipped with sprinkling and humidifying devices. These greenhouses have been used to grow about 5000 seedlings of *Eucalyptus* spp., 800 of *Taiwania*, 700 of *Tsuga chinensis* and 500 of *Calocedrus*. These plants will be used to compare hardiness of seedlings and mature individuals of the same species.
B. Laboratory (former headhouse) adjacent to greenhouses. Approximately 15′ × 40′, used to house freezers and as a wet laboratory.
C. Roof garden. Approximately 1500 square feet made available to Professor Kohn. Provision for watering and lath shading available.
D. Four experimental plant beds, each approximately 800 square feet.
E. Two walk-in cold rooms.
F. Two walk-in controlled-environment chambers.

III. Equipment

A. Ten freezers (eight purchased with funds provided by the Arboretum Foundation). These are used as follows:
   1. Six as low-temperature controlled-environment chambers for seedling studies. These have been designed to provide for different root and shoot temperatures.
   2. Four freezers for cold tolerance testing. One of these is located at the University of Washington.
B. Fluorescent light fixtures (bought as surplus by Professor Kohn from "consulting funds" provided in Arboretum Foundation grant).
   1. Seven very high-output, six-foot, four-bulb fixtures. To be set up over low-temperature controlled-environment freezers in which intact living seedlings will be tested.
   2. Thirty-one six-foot, two-bulb fixtures. For use in greenhouse hardening/dehardening work, to control photoperiod.

IV. Labor

A. Professor Kohn's time has been paid for in part by "consulting funds" provided by Arboretum Foundation grant. Much additional time has been donated by Professor Kohn and by WWU.

Left: greenhouse. Right: roof garden. Photos: Courtesy Cold Resistance Laboratory, WWU

B. Hourly labor. Professor Kohn has been successful in interesting several students in this project. Many have contributed their time. Others have been paid from funds obtained by Professor Kohn (contributions from local business clubs in Bellingham; also WWU work-study program).

V. Program status

A. Hardening/dehardening curves have been obtained for the following plants in the UW Arboretum:

Taiwania cryptomerioides (4 years)
Eucalyptus niphophila (2 years)
Rhododendron 'Brocade' (2 years)
Nothofagus dombeyi (2 years)
Nothofagus cliffortioides var. *Solandri* (1 year)
Tsuga chinensis (1 year)
Mahonia 'Arthur Menzies' (2 years)
Sarcococca saligna (2 years)
Cornus florida var. *urbiniana* (2 years)
Hydrangea integrifolia (2 years)
Choisya ternata (2 years)
Eucalyptus mitchelliana (2 years)
Garrya elliptica (2 years)
Machilus yunnanensis (1 year)
Acer oblongum (1 year)
Camellia reticulata (1 year)
Ceanothus hybrid (1 year)
Sciadopitys verticillata (1 year)
Adenocarpus decorticans (1 year)
Austrocedrus chilensis (1 year)
Cistus laurifolius (1 year)
Cistus 'Elma' (1 year)
Quercus suber (1 year)
Laurus nobilis (1 year)

B. Special studies (see "Progress in 1977-79" above)
   1. Hardiness of plants grown in lath house and in open.
   2. Supercooling in *Mahonia* 'Arthur Menzies'.
   3. Artificial dehardening of cut twigs.
   4. Comparison of hardiness of seedlings and mature plants of the same species (in progress).

C. Professional reports and publications. Professor Kohn presented four papers at the meeting of the Northwest Scientific Association, held at WWU on 29 March 1979. Two of these concerned frost tolerance in native conifers and hence were only peripherally related to the Arboretum cold resistance work. Abstracts are attached to this report.

D. Program review. Professor Jacob Levitt, an internationally recognized authority on cold and drought stress, visited the Bellingham Cold Resistance Laboratory in 1979, and presented two seminars at the University of Washington on the following day. A photocopy of his letter to Professor Hatheway, in which he offers several observations on the Bellingham facility, is attached.

E. Introduction of marginally hardy plants. In December 1978, Professor Hatheway visited Costa Rica and returned with cuttings of a number of high- and mid-elevation Costa Rican plants. Many of these were successfully rooted, using mist-house facilities very kindly provided by Mr. William Griswold, a member of the Arboretum Foundation Board of Directors. They are now housed at the UW Arboretum. A few high-elevation Hawaiian plants of potential ornamental value were introduced to the Arboretum in March 1979.

Seed of many interesting trees and shrubs native in southern Chile were sent to the Arboretum by a Chilean collaborator. Unfortunately, they had been roughly handled by the Chilean plant quarantine service, and only a few successfully germinated. We will continue our efforts to obtain viable seeds of woody plants of southern Chile. We will, of course, study the cold resistance of these new plant materials as soon as enough living material is available for testing.

FUTURE OF THE COLD RESISTANCE LABORATORY AND PROPOSED PROGRAM

When the Ornamentals Hardiness Program was established in 1975, it was proposed eventually to transfer much of the laboratory to Seattle. A principal objective, then, was to purchase and build equipment and to learn how to operate it. Professor Kohn was hired as a consultant to advise investigators at the University of Washington on equipment purchase and operation.

It was fully appreciated in 1975 that virtually no space was available in Seattle for a Cold

Resistance Laboratory, but it was hoped that construction at Union Bay would begin within a few years and that by 1980 at the latest much equipment could be installed at a new Arboretum Research Laboratory. Quite clearly, in the summer of 1979 that goal is virtually as distant as ever.

On the other hand, a highly viable Cold Resistance Laboratory and Program has been built up at Western Washington University, one which can: (1) carry out cold resistance studies for the Arboretum through the simple and successful expedient of shipping test material to Bellingham by bus or private automobile; (2) carry out special studies of several sorts (e.g., comparison of seedling and mature plant resistance, studies of the role of supercooling in frost resistance, studies on chilling resistance in tropical mountain plants); (3) enter into cooperative studies with scientists at the University of Washington and elsewhere; (4) do contract work for other arboreta and botanic gardens (e.g., it should be possible to conduct frost resistance studies on species of *Rhododendron* for the Rhododendron Species Foundation); (5) carry out studies on very low temperature of frost resistance in native timberline conifer species of western Washington state.

In our judgment, there is no need and little justification for phasing out the Ornamentals Hardiness Program at this juncture. It has clearly met and, in many cases, exceeded the goals that were set for it at its inception. Much, however, remains to be done. *Among highly worthwhile projects are the following*:

I. Comparison of frost resistance of seedlings and mature plants of the same species

As we have already noted, seedlings of species of *Eucalyptus, Tsuga, Taiwania* and *Calocedrus* have been grown at WWU, and six freezers have been successfully modified as low-temperature controlled-environment chambers to accommodate these seedlings (these freezers can be readily converted back to carry out conventional cold-resistance studies). This study is planned for the winter of 1979-80.

II. Hardiness testing of potential introductions to the University of Washington Arboretum

There are many species now being grown in Oregon and northern California which we are reluctant to introduce to Seattle because they are of questionable hardiness. Some testing of this material is certainly possible in the fall and winter of 1979/80.

III. Hardiness testing of certain tropical and subtropical mountain plants

This work depends entirely on availability of plant material.

IV. Hardiness testing of plants of Southern Hemisphere origin, particularly from Chile, New Zealand and Australia

This again depends on availability of material. As already noted, interesting plants are already available in Oregon and northern California.

V. Preparation of a proposal to the National Science Foundation

During our discussions with Professor Levitt we learned that much recent work on chilling injury has stressed changes which take place in the physical state of the cell membranes at temperatures of 10° to 12°C. We have reason to hypothesize that certain abrupt changes in the floristic composition of the vegetation of tropical mountains (sudden abundance of oaks, cherries, viburnums, etc.) above certain elevations (e.g., about 1800 meters in Costa Rica, somewhat higher in Colombia and Ecuador) are related to a change from chilling-susceptible species at low elevations to chilling-resistant species at higher elevations. Experiments designed to test this hypothesis might be of considerable interest to funding agencies such as the National Science Foundation. Preliminary experiments would enhance the plausibility of these hypotheses and hence the likelihood that our proposals would be favorably received.

We suggest that in view of these attractive possibilities, the Ornamentals Hardiness Program be extended for two years, *at no additional cost to the Arboretum Foundation*. Money remaining from the original grant would be spent in the following ways:

I. Purchase of control equipment

As Professor Levitt points out in his letter to Professor Hatheway of June 13, 1979 (photocopy attached), " . . . what Hubertus [i.e., Professor

Kohn] must do, however, is obtain the necessary automatic controls (if possible, computerized) that will lower the freezer temperature at the desired rate and enable him and his students to devote their time to other duties, rather than running back and forth to the freezer at all hours of the day and night in order to control it manually!"

II. Hiring reliable hourly help

Professor Kohn believes that it should be possible to hire a responsible person on a part-time basis to help him with many routine but necessary chores, such as removing test twigs from the freezer to the cold room and maintaining them until they are ready for evaluation of frost damage.

III. Payment of transportation expenses, both travel to and from Bellingham, and shipping plant material from Oregon and California to Bellingham

IV. Payment of expenses of proposal preparation

About 35 copies of a proposal are normally prepared (NSF alone requires 20). Duplication and mailing charges are appreciable. In addition, photocopying of journal articles is necessary for efficient literature review. ♠

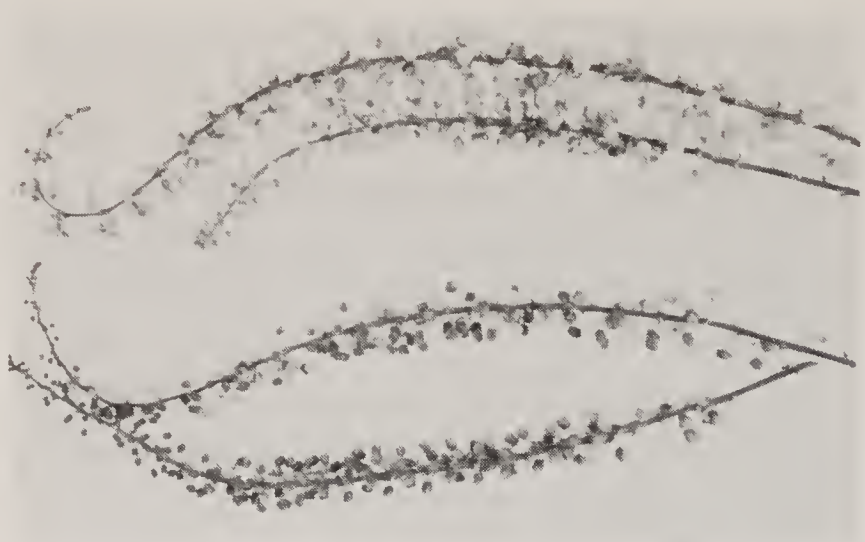
Mahonia 'Arthur Menzies' Supercools —Probably

A visitor to the Arboretum's Winter Garden is often rewarded during the late fall and early winter months by a gorgeous display of flowering witch hazel *(Hamamelis mollis* and other species). In a somewhat wilder setting, one of us (WHH) vividly remembers trudging through a mixed deciduous forest in central Massachusetts in late November in a virtual blizzard and coming upon a witch hazel *(H. virginiana)* bush in full flower. Air temperature was well below the freezing level. One naturally wonders what kinds of pollinating insects are abroad in such inhospitable weather (they are probably certain kinds of flies), and if one thinks further, one also wonders how the living active tissues of such flowers avoid frost damage or even death. After all, many of us have suffered the disappointment of seeing an early-flowering rhododendron's cheerful display reduced to mush by a sudden spring frost. How are some flowers able to shrug off these sharp freezes while others apparently lack even the slightest resistance to frost?

Attempting to find answers to some of these questions, we chose the Arboretum's handsome new hybrid, *Mahonia* 'Arthur Menzies',[1] for careful study. 'Arthur Menzies' is a convenient subject because, like many witch hazels, it flowers in very late fall and early winter (November—January). At the Arboretum there is the additional advantage that a mature specimen is planted near the Arboretum headquarters building, where a continuously recording thermometer is installed.

Preliminary work had led to the working hypothesis that the actively growing flowers of 'Arthur Menzies' avoid frost damage because the water in their tissues fails to freeze, although air temperatures drop to −10° to −14°C. This failure of water to freeze at sub-freezing temperatures is known technically as "supercooling". In laboratory studies of freezing phenomena it is not unusual for water to remain in the liquid form at temperatures as low as −25°, and, if special precautions are taken, it can be supercooled to about −40°C. Supercooling is known to occur in azalea buds, in the living tissues of twigs of several species of pears and in the flower buds of many species of plums. The twigs, inner bark and living tissues of the wood of many species of deciduous trees native in the eastern United States have been found to supercool, some to −40°C. Interestingly, the conifers and deciduous trees, such as aspen and paper birch, which occur in the boreal forests of central and northern Canada and Alaska, do not supercool but instead are frost resistant. That is, although ice forms in their tissues (between the cells, not inside them), the tissues generally are not damaged, except in the most severe winters. They resume their normal activities with the onset of spring. It has even been suggested that the U.S.-Canadian border de-

[1]The Arboretum's hybrid, *Mahonia* 'Arthur Menzies', was first described in the *Arboretum Bulletin* by J.A. Witt in Spring 1967, Vol. XXX, No. 1.



Racemes of *Mahonia* 'Arthur Menzies'. Below: sprayed with mist and killed by cold. Above: dry and undamaged at the same temperature. Photo: Courtesy Cold Resistance Laboratory, WWU

lineates approximately the zones of vegetation dominated by frost-resistant and frost-avoiding (supercooling) plants!

To test the hypothesis that flowers of *Mahonia* 'Arthur Menzies' supercool during periods of low temperatures and resume growth and development on warm days, we subjected racemes containing both open flowers and flower buds to wet and dry frosting in the Cold Resistance Laboratory in Bellingham. Racemes previously cooled to −4°C were sprayed with a very fine water mist. The resulting droplets froze almost instantaneously. These ice crystals, which formed first on the surface of the flowers, apparently then grew into the tissues, causing the death of affected cells. Racemes in the same stage of development and subjected to the same temperature treatment, but not sprayed with water, were not damaged.

A corollary experiment was conducted in the Arboretum last winter during the severely cold period in late December. Several plants of 'Arthur Menzies' were in full flower in the nursery. A fine mist of chilled water was sprayed on one spike of flowers in an inflorescence while the adjacent spikes were protected from the mist. The air temperature was about −7°C, and ice crystals formed almost instantly on the sprayed florets. This treated spike and an adjacent untreated one were harvested next morning and, upon thawing, the misted flowers soon turned brown while the protected florets showed no sign of injury even though the air temperature had dropped to −13°C during the night.

We wish to emphasize that these results require further checking, including the study of graphs of flower tissue temperatures as the flowers are subjected to slow cooling. A steadily decreasing temperature curve, followed by a sudden rise, is a definite indication of supercooling followed by solidification (i.e., freezing) of the water in the flower tissues. The rise in the temperature curve is caused by the release of what is technically known as the "latent heat of fusion". This release occurs as the water passes from the liquid to the solid state.

So far as we are aware, this is the first report on studies of the freezing behavior of winter-flowering plants. Obviously, it will be important to confirm these results in 'Arthur Menzies' and perhaps to extend them to other plants of horticultural and scientific interest. It is, of course, entirely possible that we will find that mechanisms other than supercooling predominate in witch hazel and many other winter-flowering plants.

A central mystery remains. We know that the living parts of many plants avoid frost injury by supercooling, but we do not know *how* they do it. Supercooling, after all, is something of a laboratory feat. We know that it seldom happens in refrigerators and home freezers, because ordinarily we have little difficulty in producing ice cubes and frozen vegetables. What, we may ask, prevents the water in the spaces between the cells that make up the living tissues of 'Arthur Menzies' flowers from freezing? The most we can say at present is that the changes which take place in water as it cools appear to be affected by the fact that the tissues of plants are divided up into discrete compartments—the cells, and the spaces and cell walls that separate them. Because of this compartmentation, the freezing process is not quite the same in living plants as it is in a laboratory beaker or an ice-cube tray. Of course, this compartmentation is common to all plants, but

Flowers of *M.* 'Arthur Menzies'. Right: killed. Left: undamaged. (See caption above.) Photo: Courtesy Cold Resistance Laboratory, WWU

some are better supercoolers than others. It is fair to say that we simply do not know why this should be.

The heavy guns of modern science are now being trained on these interesting problems. The weapons include electron microscope observations of the freezing process, X-ray diffraction analysis and nuclear magnetic resonance studies of non-equilibrium freezing of aqueous systems. In other words, the ball is in the court of specialists in experimental thermodynamics. Those of us who are active in the field of cold resistance in plants look forward to the results of these studies with great anticipation. Ultimately they will account for many of the differences between hardy and non-hardy plants.

As an aside, the Arboretum's plants of 'Arthur Menzies' have become a favorite feeding station for Anna's hummingbird and even during the depth of last winter's cold this tiny bird was seen getting nectar from the open flowers.

H. KOHN, W.H. HATHEWAY and J.A. WITT

Programs and Exhibits

The Vancouver Island Rock and Alpine Garden Society is hosting the Fifth Pacific Northwest Study Weekend at the Empress Hotel in Victoria on February 29th through March 2nd. Among the lectures will be the following:

Mr. Alfred Evans, Assistant Curator of the Royal Botanical Garden at Edinburgh and author of *The Peat Garden*, will speak on the rock garden at Edinburgh and on peat gardens.

Mr. Francis Cabot of New York will describe rock and wall gardens in that state.

Mr. Reuben Hatch of Vancouver, Washington will speak on his recent trip to Kashmir and on primulas.

Mr. Larry Aguilar of Qualicum Beach, B.C., a member of the American Bonsai Society, will demonstrate training and collecting bonsai.

Mr. Panayoti Callas of Colorado will speak of alpine plants in that state.

Registration forms may be obtained from the Northwestern Chapter of the American Rock Garden Society. Registrations will be accepted by Mrs. R.T. Batey, 1 - 1005 St. Charles Street, Victoria, B.C., Canada V8S 3P9.

The Northwest Ornamental Horticultural Society's 1980 lecture series is entitled "Plantscape 1980-2000". The four lectures will be held on Thursdays at the Museum of History and Industry with an admission charge of $2.50. Students will be admitted for $1 to all but the evening lecture by Lawrence Halprin. The program is as follows:

February 14 - 10:30 AM: "Growth-Green, Asphalt or Both". Lecturer: James Ellis

March 13 - 10:30 AM: "Urban and Suburban Planning for the Survival of Plantscape". Symposium with Darel E. Grothaus, Karen Rahm, Walter Hundley, and James E. Webster

April 10 - 10:30 AM: "How to Landscape Under New Growth Pressures—Citizen Responsibility". Symposium with Betty Miller, Edward MacLeod, Joseph A. Witt, and Marvin Black

May 8 - 7:30 PM: "Preserving the Quality of Landscape". Lecturer: Lawrence Halprin of San Francisco—Environmental Designer, Town Planner, Landscape Architect, Author

The Arboretum Foundation's Unit Council is sponsoring a number of programs in February and March:

1. A WINTER LECTURE SERIES at the Museum of History and Industry.
2. A GREENHOUSE MANAGEMENT SERIES taught by Richard van Klaveren.
3. The THIRD ANNUAL HORTICULTURAL EXHIBIT at the Museum of History and Industry, March 25 and 26.

The two series of lectures are open to the public as well as Foundation members, and *everyone* is invited to attend the exhibit. See pages 40-41 for details.

Pittosporum tobira survived last winter's freeze in the Arboretum.
Photo: Brian O. Mulligan

Winter Damage in the Arboretum 1978-1979

JOSEPH A. WITT

As was previously reported in this *Bulletin* (42:1,3; Spring and Fall, 1979), the winter of 1978-79 was a severe one which jolted us out of our complacency of the past six years. It reminded us that Seattle is, after all, the most northerly large city in the United States and that we should expect killing winters every five or six years.

The cold period began on December 27 when the minimum temperature that night reached a modest 28°F; however, on the 28th the maximum was also 28°F and for the next five days, until January 2, the maximum never rose above 29°F. The minimum temperatures during the most intense cold were all 17° or below, with the thermometer reading 10°F on the night of December 30. This reading was undoubtedly much lower in some areas of the Arboretum; for instance, we recorded 7°F in the nursery and it seems probable that some of the traditionally colder areas such as the Japanese Garden may have been several degrees below that. Even though the maximum temperatures finally stayed above 32°F after five days, the daily minimums were in the low- to mid-20's for another seven days.

This cold did give us a number of surprises. Although it was as severe as in past years when many half-hardy plants were decimated, the damage to the Arboretum's collections was not as bad as might have been expected.

Certain groups of plants did suffer—for instance *Gaultheria shallon*, salal, had much of its foliage burned and its tops killed over the entire region. One may speculate that part of this behavior was due to prior conditioning from drought. Plants which had been set out recently, either in the spring or fall, had their troubles—for instance, many of the large-leaved rhododendrons of the Falconeri or Grande types planted on a west-facing bank in April suffered to the extent that many will need replacement.

The rock rose collection (*Cistus*) was in sad condition, as is usual after a cold period, although by mid-year even the most damaged plants were still struggling to put out new growth. Again, it was the recently planted individuals that were killed outright. The *Ceanothus* were most unhappy but, while much wood injury and leaf burn appeared within a month after the cold, nearly all species and cultivars survived. They were given a sharp pruning in April, which seems to have aided in their recovery.

Eucalyptus species have always suffered in our colder winters, and we expected to see a wholesale slaughter of them again. However, much to our surprise, the trees in our collection came through remarkably well. Many had badly burned foliage, a few lost buds and new wood, and a very few were killed to the ground. We have

speculated that the relatively dry and warm fall may have conditioned those which survived against the cold, but we have no evidence to back this supposition. Previous experience led us to expect damaged flower buds on those early-flowering magnolias which are native to the Himalaya mountains and/or southwestern China. Actually, *Magnolia campbellii* and its variety *mollicomata* flowered beautifully in the spring as did *M. dawsoniana*, *springeri* 'Diva' and *sargentiana* var. *robusta*. Interestingly enough we saw rather severe flower-bud damage to the hybrid between *M. campbellii* and var. *mollicomata*. Since plants in two very different locations had the same degree of injury, we believe that this was due to cold damage, not to some unusual environmental condition found in one site or the other.

The camellia collection came through with very mild injury; some leaves were burned and there were a few species and cultivars whose flower buds were ruined. No plants were killed, however, and flowering in the spring appeared to be nearly normal.

Our rhododendrons did suffer more, as was mentioned above; a number of young plants were damaged to the extent that they were unable to cope with the drought conditions of this spring and summer. However, well-established plants survived with minor leaf burn, and the majority of species and hybrids flowered beautifully this spring. Our greatest loss was in a group of azaleas growing in the cold frames. Many of these plants were killed at the ground line despite the fact that they were propagated from azaleas which had not been injured, and that the frames were covered during the entire cold period. It is possible something more than cold was responsible for this loss.

In retrospect, last winter was not as damaging as the low temperatures indicated it might have been. In some ways it was interesting and gave us some conundrums to puzzle over. For instance, why did we have so much injury to certain heathers which in past years had not been fazed by similar conditions? Why was native salal so badly burned? Why were certain brooms (*Genista* and *Cytisus*) injured for the first time in many years? As mentioned above, we suspect the drought had much to do with this unusual pattern of plant damage. Our precipitation records show that we have had a deficiency of rain dating back to 1976 and that since January 1976 we have been short about 544 mm (21.4 in) precipitation for the three-year period. During this same time the deficiency for our three wettest months—November, December and January—has been 574.8 mm (22.7 in). We noticed that many of the plants which suffered the most damage were those from a mediterranian type of climate, that is, one in which there is a distinct winter-rainfall/summer-drought pattern. Could it be that those species acclimated to heavy winter rains were more susceptible to cold injury because the last three winters were much below the average in precipitation? Conversely, we might speculate that plants which evolved under a regime of equally distributed annual rainfall or a pattern of summer-rain/winter-drought might have been better adapted to face a cold winter.

Below are lists of Arboretum plants categorized by the way they reacted to the cold period. These lists are by no means complete, rather they are intended to give a cross-section of what happened during the winter of 1978-79.

Plants killed to the ground:

Billardiera longiflora, some new growth from ground 8/79
Camptotheca acuminata
Cistus albidus, newly planted
C. crispus, newly planted
C. psilosepalus, newly planted
C. × *purpureus,* newly planted
Cordyline australis, recovering from roots 8/79
Dendromecon rigida, recovering 8/79
Eucalyptus nicholii
E. nova-anglica, new growth from base of stem 8/79
Eugenia chequen, in nursery, some new growth 8/79
Lavandula stoechas
Lithodora diffusa 'Grace Ward'
Olearia albida, in lath house
Phlomis italica
Pistacia terebinthus, in lath house
Quercus species, collected in Mexico 1967
Salvia regla
Vaccinium delavayi, in lath house

Plants with severe leaf burn or damaged wood, but which recovered with little obvious injury:

Acer oblongum, defoliated
Ardesia japonica, foliage burned
Azara lanceolata, nearly defoliated in lath house

Bursaria spinosa, defoliated
Camellia reticulata, one plant flower buds killed, others OK
C. × 'Innovation', moderate leaf burn, some buds killed
Carpenteria californica, severe leaf burn
Ceanothus, most species and cultivars
Cistus, most species and cultivars
Cornus capitata, defoliated
Daphne odora, defoliated
Desfontainea spinosa, in lath house
Erica, even damage to most species and cultivars
Eucalyptus gunnii
E. mitchelliana
E. moorei
E. pauciflora
E. perriniana
Eucryphia × *intermedia* 'Rostrevor', severe burn, flowering 8/79
Eucryphia × *nymansensis*, badly burned
Garry elliptica, leaves burned, flowered Feb. & March, 1979
Glyptostrobus lineatus, in lath house
Hydrangea integrifolia, badly cut even in cold frame
Leucothoë populifolia, leaves and tips of shoots killed
Mahonia 'Golden Abundance', many flower buds killed, leaves OK
Nothofagus solandri var. *cliffortioides*, leaves burned
Persea borbonia, nearly defoliated
Quercus species, four evergreen oaks from high elevations in Mexico all were badly leaf-burned
Quercus suber, foliage badly injured
Rhododendron amesiae, nearly defoliated
R. calostrotum, nearly defoliated
R. davidsonianum, some plants on west facing bank had severe leaf scorch
R. spiciferum, severe foliage burn
Schisandra propinqua, partially defoliated

Some pleasant surprises. The following could well have been expected to be killed but were relatively undamaged:

Callistemon ?viridiflorus, against south wall of greenhouse
Dacrydium intermedium, in lath house
Drimys lanceolata, in lath house
Euonymus japonicus 'Microphyllus', in lath house
Eurya 'Winter Wine', in lath house
Fokienia hodginsii, in lath house
Hoheria glabrata, in several locations, flowering 7/79
Libocedrus bidwillii, in lath house
Neolitsea sericea, in lath house
Pieris phillyreaefolia, in lath house
Pittosporum tobira, in several locations
Taiwania cryptomerioides, in nursery and lath house

♠ ♠ ♠ ♠ ♠

The Winter of 1978/79, Richland-Style

Herbert Parker described his experiences gardening under the climatic conditions of eastern Washington in the summer issue of the Arboretum Bulletin *(Vol. 42, No. 2, 1979). This letter to Mr. Witt is a follow-up, describing the effects of last winter's cold.*

July 6, 1979

Dear Joe,

You expressed an interest in our winter damage following our worst winter of the century. The season is far enough along to make a judgment.

The term "worst winter" is quite arbitrary. It was not the coldest by any means. Neither was it one with a sudden early freeze that can be quite devastating. Its feature was a 30-day spell at the beginning of the year with the temperature never above freezing. The ground at our meteorological station (more exposed than we are) froze to about 36 inches. I would have expected the worst damage to shallow-rooted broad-leafed evergreens which could not replace moisture in the leaves.

Certainly all the *Mahonia aquifolium* in exposed areas throughout town was a dried out mess. Today, with a minimum of judicious snipping you would not know that there had been a problem.

Roses have been the most affected. I do not profess to be a dedicated rose grower, but I had hilled up most of them. My losses were about 10 percent but some survivors have weak stems that go down—especially the heavily clustered Floribundas ('Europeana' seems especially vulnerable). Rose experts in town tell me that good plantings have had a 10 to 20 percent loss. Those not properly hilled have losses up to 80 percent.

Apart from the roses, I lost only one or two deciduous shrubs or trees. One was an *Acer palmatum*. I suspect that it was failing in the fall, and its demise more connected with summer watering than winter cold. Other *A. palmatum*s were not affected at all. The other complete loss was a *Pyracantha* [*coccinea*] 'Government Red'. The 'Lalandei' survived with the loss of a branch or two.

The hollies were of particular interest. About a dozen looked bad in the spring, but not a single one is dead. Until a week ago I would have said that 'Golden Queen' was gone, but lo and behold! it put out leaves this week. It was the most susceptible, according to my arguments about viable chlorophyll areas. This 'Golden Queen' is the female golden variegated plant that is officially 'Golden King' in England. I had listed it as *Ilex aquifolium* but according to a British reference it is *I.* × *altaclarensis* and it so appears in your *Woody Plants*. All the *altaclarensis* hybrids tend to be a bit less hardy than *aquifolium*. For example, the 'Wilsonii' lost most of its leaves and 'Camelliaefolia' had a few browned ones.

Whereas the English hollies were shaken up and are now recovering, the Chinese hollies (*Ilex cornuta*), not so affected at first, are perhaps going downhill now. Although the 'Burfordii' is technically alive, I am contemplating a mercy killing.[1]

The *cornuta/aquifolium* cross 'Nellie R. Stevens' is behaving more like a *cornuta*. Fortunately it was too big and will end up a better size.

The Japanese and American hollies seem to be entirely unaffected.

The rhododendrons all bloomed except 'Cotton Candy'. There are some browned leaves on most of the plants, now covered by new growth.

Genista lydia, listed as too tender for us, formed the usual sheets of bloom. I am conviced that its hardiness is quite underrated.

Elaeagnus pungens was set back to the ground but is filling out.

All the magnolias bloomed. *Liliflora*, which seemed to have blasted its buds, pulled itself together and bloomed late. Even *Magnolia wilsonii*—not really stable here—made modest bloom. Other relatively sensitive trees fared quite well. For example, *Stewartia pseudocamellia* was loaded with bloom, but some others did badly.

All the viburnums did well except *Viburnum davidii* which often kills to the ground. My only other evergreen virburnum, the leatherleaf (*V. rhytidophyllum*) grew mightily and will have to be moved.

Abelia grandiflora, not a very hardy plant, was surprisingly not set back to the ground. It flowered this week as did the silk trees.

Among the cotoneasters, *Cotoneaster franchetii* lost its top layer. Neither *C. dammeri* nor *C. horizontalis* was disturbed.

None of the conifers was visibly affected by the winter.

Fruit and nuts are doing well. We have eaten our way through the cherries and are now into raspberries. The apricots are ripening, as are early plums. Pears are either loaded or have no fruit whatsoever ('Bosc' and 'Seckel'). This has never happened before. Plum blossom was unbelievably heavy and we have resorted to thinning, which we normally do only on the bigger fruits. Walnuts and chestnuts have heavy crops.

We were at Opal Brown's (in Milton-Freewater) the other day. Her conditions were similar to ours. In fact, she has a 'Golden Queen' holly that is behaving a little better than ours. However, her silk trees, which are offspring of ours, were set back to the ground. These seem to be decidedly more tender until they get to be several years old.

One thing that happened to both of us, which as amateurs we cannot understand—a number of trees of about the 10-year-old class have an isolated branch or branchlet that is dead, with no other visible

[1]Mr. Parker has since replaced the 'Burfordii' and also aquired a 'Burfordii' dwarf with which he is delighted.

damage. The location of these injuries seems to be entirely random, often on what superficially appears to be the more sheltered aspect. The victims are deciduous trees in my case, but include conifers at Opal's. She has a Spanish fir (*Abies pinsapo*) that has one dead limb but otherwise has put on a beautiful set of cones for the first time. Are these casual injuries after a severe winter a phenomenon well recognized by the experts?[2]

We also think that certain plants have flourished unusually well. Our first iris blooms were exceptionally good, but both the number of buds per stalk and the number of offsets per plant were below par. You could rationalize that as a product of the weather. In addition to the dense plum blossom, we are now enjoying lilies the like of which we have never seen before, although they are all the same Prof. Samuelson's hybrids that we have had for over 10 years. I am looking *up* at one flower head with 25 open blooms and more to go.

If there is any particular plant type that you are interested in, which is not included here, let me know.

Our regards to Jean.

Sincerely,
Herb

[2]Mr. Witt suggests that this phenomenon, which is also seen in the Seattle area, may be due to previously unnoticed stress (injury perhaps) to isolated branches, which then fell prey to last winter's severe cold.

Winter Damage at the Carl S. English, Jr., Gardens Hiram M. Chittenden Locks (Ballard)

Since the microclimate of the gardens at the "Ballard Locks" in Seattle is moderated by their proximity to Puget Sound, the damage (or lack of it) experienced there should be of particular interest to those who garden in a similar locality. During the winter of 1978/79, the lowest temperature recorded at the Locks was 18°F. This is eight or more degrees milder than temperatures recorded at the Arboretum during the same period.

The following information was supplied by Greg Simmons, Assistant Gardener.

Plants that suffered leaf drop or browning, shoot dieback or died to the ground:

- *Billarderia longiflora*—shoot dieback.
- *Callistemon citrinus* 'Splendens'—dead to the ground.
- *Cistus salviifolius*—60% leaf drop and browning, some shoot dieback.
- *Danae racemosa*—25% leaf drop and browning.
- *Dendromecon rigida* ssp. *harfordii*—10% leaf browning, some shoot dieback.
- *Eucalyptus* sp.—80% leaf drop and browning.
- *Gaultheria shallon*—40% leaf browning and shoot dieback.
- *Hypericum androsaemum*—dead to the ground.
- *Lapageria rosea* var. *albiflora*—dead to the ground.
- *Lithocarpus densiflorus*—50% leaf drop and browning.
- *Pernettya mucronata*—30% leaf browning.
- *Quercus dumosa*—60% leaf drop and browning.

Plants that suffered snow damage:

- *Ceanothus thyrsiflorus*—all branches broken.
- *Pinus sabiniana*—40-foot tree came down.
- *Quercus suber*—20-foot tree lost its top.

Plants that showed little or no damage:

- *Callistemon subulatus*
- *Chamaerops humilis*
- *Camellia reticulata*
- *Choisya arizonica*
- *Pinus patula*
- *Quercus: agrifolia, glauca, hypoleucoides, reticulata, suber, vacciniifolia, wislizenii*
- *Trachycarpus fortunei*

President's Message

As reported in the last issue, things are really moving right along. I am pleased to report that the Master Plan Update for the Arboretum in Washington Park has now been approved by both the Seattle City Council and the Board of Regents of the University of Washington. The approved plan includes:

—a new irrigation system replacing an outmoded one.

—a new Visitor Center with offices for the UW's Arboretum staff, offices for the Arboretum Foundation, and space for meetings, exhibits and a guided-tour assembly area.

—a new teahouse in the Japanese Garden, with increased security and maintenance throughout the garden.

—new facilities for maintenance of equipment.

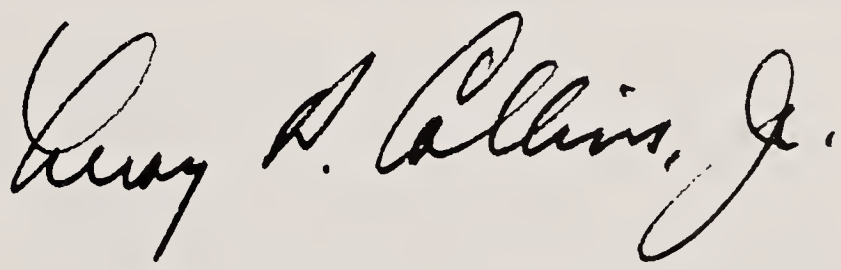
—new or improved plantings.

—improved access for mobility-impaired persons.

The changes in roads and bicycle paths envisioned in the Plan could not be considered by the Council and Regents at this time because they will be influenced greatly by the results of a thorough study being conducted of all traffic in the area encompassed by I-5, I-90, Lake Washington and the UW. Seattle City Council's Transportation Committee under Councilwoman Jeanette Williams will consider the study when it has been completed.

As for funding, the teahouse will be rebuilt by donations, the drive to begin soon. The Arboretum Foundation plans to build the Visitor Center and donate the completed structure to the City. Designs and architects are being sought so that construction can commence without undue further delay (Vice-President Donald Close has been named chairman of the Visitor Center Building Committee). Our plans will, however, be subject to further approval by the Council and Regents. Funding for the irrigation system, maintenance facilities and other improvements will be initially dependent upon trust funds resulting from the cancelation of the R.H. Thomson Expressway.

The forward steps outlined above should bring joy to the hearts of those who have long wanted such facilities. This is truly becoming a great year.



Membership in the Arboretum Foundation is a Commitment to the Arboretum's Future

1980 is the year to

—join the Foundation

—renew membership

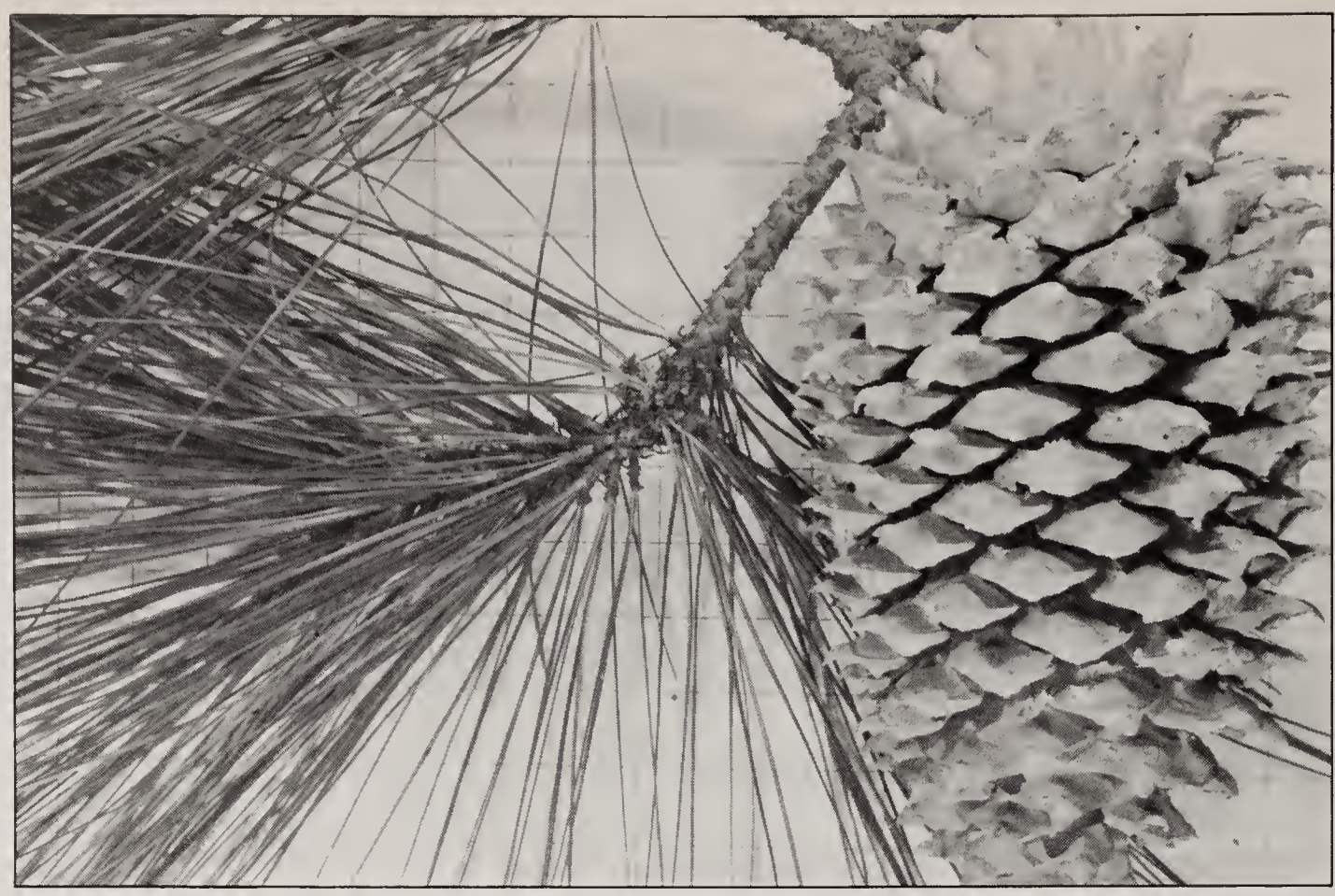
—raise your level of membership

1980 is the year that we shall

—begin the Visitor Center and the Japanese Teahouse

—achieve other major improvements in the Arboretum

Annual	$10	Sustaining	$20-35
Family	$15	Contributing	$35-60
Over 65/under 21	$5	Supporting	$60-100
Group affiliation	$15	Sponsor	$100-500
Life	$500		



Pinus coulteri.

University of Washington Campus Conifers

*C. FRANK BROCKMAN**

Editor's Note: In the preceding issue of the Bulletin, *Professor Brockman discussed some UW campus trees notable for their historical interest. He describes below the species of conifers represented in campus plantings, indicating their location and more important identifying characters. All illustrations in this article were photographed by the author against a one-inch wire grid to indicate the scale of the various species.*

The subject of this article requires elaboration. It deals with species in one of the two principal classes of trees known botanically as *gymnosperms.* A basic characteristic of such trees is that their seeds are borne naked, usually on the scale of a cone, in contrast to the seeds of the other basic class of trees, known botanically as *angiosperms*, which are protected by the covering of an ovary (for example, walnuts, apples, cherries). There are exceptions to such terms as "evergreen" or "conifer" which are commonly applied to gymnosperms. They are not always evergreen, nor do they always produce seeds in cones.

PINACEAE (THE PINE FAMILY)

Pinus

Pinus aristata (bristlecone pine)

Native to Colorado and Arizona, *P. aristata* is related to and was once thought to include the species *P. longaeva* which is considered to be the oldest of living things. A gnarled specimen of the latter species in the White Mountains of eastern California is, by actual ring count, 4900 years old.

Characters: Bristlecone pine has needles one to two inches long in bundles of five, which remain on the branches 10 to 15 years, giving the branches the appearance of a foxtail. Both the needles and the small prickly cones are speckled with minute flecks of gray resin.

Location: Small specimens may be seen in front of the Burke Museum, near the Faculty Center and about the buildings of the College of Forest Resources.

Pinus coulteri (Coulter pine)

Native to the foothills of coastal California.

Characters: Pinus coulteri is noteworthy for its large, oblong cones—the heaviest of any pine—composed of thick, woody, long-pointed, claw-like scales. The blue-green needles, 10 to 12 inches long, are in bundles of three.

Location: Several Coulter pines can be seen along Stevens Way opposite the rear of Clark Hall.

*Professor Emeritus, College of Forest Resources, University of Washington.

However, the most typical specimen on campus grows near the front entrance to Winkenwerder Hall.

Pinus sabiniana (digger pine)

This species is native to foothills west of the Sierra Nevada in California and into southern Oregon. Its common name was applied by early California miners; they noted that Indians of that region, who secured some of their food by digging in the earth for roots and tubers, also ate the large seeds of this tree.

Characters: Like *P. coulteri*, *P. sabiniana* has large cones with thick, pointed scales, but these cones are globular, and their woody scales terminate in broad, triangular points. The needles, three per bundle, are gray-green and about eight inches long.

Location: Several digger pines can be found in the vicinity of the campus flagpole.

Pinus attenuata (knobcone pine)

Knobcone pine is typical of foothill forests in California and southern Oregon.

Characters: Needles are yellow-green, about five inches long and in bundles of three. The basal scales of its narrowly conical, five-inch cones are distinctly knoblike. Furthermore, they remain closed and firmly attached to the tree for long periods of time, occasionally becoming embedded in the wood as the trunk or branches increase in diameter.

Location: A good specimen grows northeast of the Home Management House.

Pinus radiata (Monterey pine)

This attractive pine is indigenous to a limited area about Monterey Bay in central California. Although it is of little interest to American foresters, it has been found to grow rapidly in South Africa, New Zealand and Australia, where extensive commercial plantations produce softwood timber.

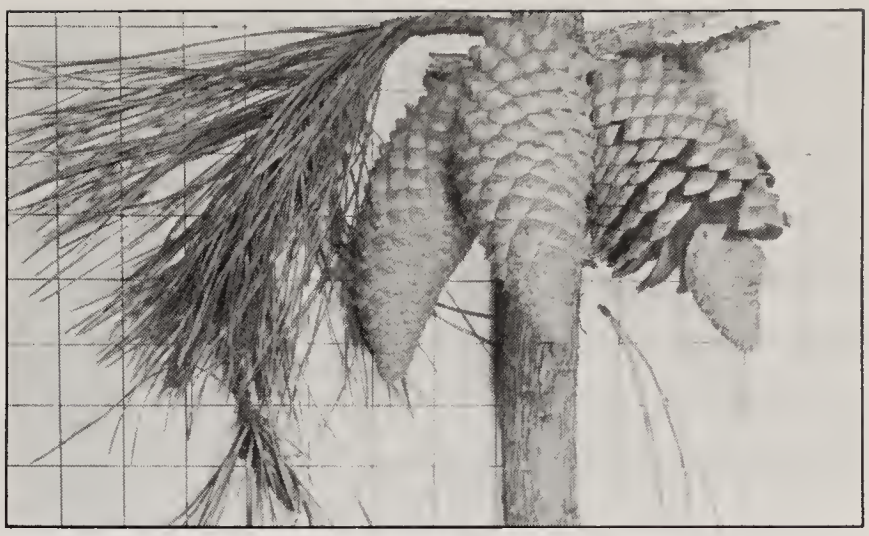
Characters: Monterey pine is typified by flexible, blue-green needles, usually three per bundle.

Location: A single specimen can be found west of Anderson Hall.

Pinus patula (Mexican yellow pine)

Native to Mexico, this pine is also widely grown on many foreign plantations.

Characters: It is distinguished by its drooping



***Pinus attenuata,* knobcone pine.**

slender needles, 10 to 12 inches long in bundles of three.

Location: A lone specimen of this species may be found in the grove along Campus Parkway.

Pinus banksiana (jack pine)

The natural range of jack pine, an inhabitant of poorer soils in colder areas, extends from the northeastern United States to the Yukon. It resembles the shore form of our native lodgepole pine (*P. contorta*), except for the cone characteristics, which are described below.

Characters: Its needles, in bundles of two, are 1 to 1½ inches long. The cones, one to two inches long, are curved at the tip and point forward toward the branch ends.

Location: One may find jack pine near the east entrance to the Art Building as well as west of Anderson Hall.

Pinus contorta (lodgepole pine)

Lodgepole pine is native on the Pacific Coast from the Yukon south to the southern California Sierra Nevada, and through the Rockies south to southern Colorado. The common name is derived from the inland form, *P. c.* var. *latifolia*, which has a straight trunk and was used by Indians for tepee poles.

***Pinus sabiniana,* digger pine.**

Characters: The species differs from jack pine in that the small cones point outward or backward on the branch. It has short needles in bundles of two and a ragged crown.

Location: It is frequently planted on campus; several specimens may be seen in the vicinity of the campus flagpole.

Pinus sylvestris (Scots pine)

Scots pine is an important timber tree in Europe; there, in its native environment, it grows with a straight trunk.

Characters: Its short needles in bundles of two are yellow-green. The cones are two to four inches long with scales flattened at the ends. The scaly bark has an orange cast, and planted in our area, the trunk is often crooked.

Location: The species is fairly common on campus. A typical specimen grows west of Anderson Hall.

Pinus resinosa (red pine) and *Pinus nigra* (Austrian pine)

These species are sometimes confused. The characters described below will help to distinguish them.

Characters: Both bear needles four to six inches long in bundles of two. Those of red pine are slender and break cleanly when doubled, while the stouter needles of Austrian pine only bend.

Location: A good specimen of red pine may be found near the northeast corner of Clark Hall. Austrian pine is more common on campus, and a good specimen is located along Stevens Way northwest of Johnson Annex B.

Pinus ponderosa (ponderosa pine, western yellow pine)

Ponderosa pine is a common conifer on drier soils east of the Cascades as well as throughout a large part of the West.

Characters: Large, mature individuals can be recognized easily by their large, scaly plates of cinnamon-brown bark. Its needles, five to ten inches long, are borne two to three per bundle on the same tree and are tufted near the branch ends. The oval cones, three to six inches long, have scales tipped with a stout stiff prickle.

Location: Rare on campus, one tree of this species west of Anderson Hall is not large enough to exhibit the bark characteristic of large trunks.

Pinus monticola (western white pine) and *P. strobus* (eastern white pine)

Since these species may hybridize, specific identification may be difficult.

Characters: Both have slender, flexible needles, three to five inches long, borne five per bundle. Those of western white pine, however, remain on the branches from two to four years to produce a relatively dense crown, while eastern white pine has a lighter crown with needles remaining on the branches for no more than two years. Furthermore, cones of western white pine are about 8 (from 5 to 15) inches long with but a slight curve, while cones of eastern white pine are smaller—about 5 (from 4 to 8) inches long—and more strongly curved.

Location: Specimens of these trees may be seen near the campus flagpole, and a particularly handsome specimen of western white pine is located east of Denny Hall.

Pinus lambertiana (sugar pine)

Sugar pine is native of California and Oregon.

Characters: The foliage is similar to that of eastern and western white pines, but the cones—about 16 (from 10 to 26) inches long—are columnar, the longest cones of any pine.

Location: The large specimen growing opposite Eagleson Hall on the west edge of campus, was mentioned in the preceding issue of the *Bulletin* (Vol. 42, No. 3, Fall 1979) as possibly being one of the trees planted by Meany.

Larix and *Cedrus*

There is a superficial resemblance between the foliage of larches and true cedars. Both have needles borne in brush-like clusters on branch spurs (singly on new growth at branch ends) but larches are deciduous conifers, while true cedars, none of which are indigenous to North America, are evergreen. Moreover, the cones of these two genera of the pine family are very dissimilar. Those of true cedar, described below, are particularly distinctive.

Larix decidua (European larch) and *L. occidentalis* (western larch)

Western larch is typical east of the Cascades where its golden-yellow autumnal foliage and light green, new spring foliage add interest to the more somber green of other conifers in that area.

Characters: This deciduous genus has small cones whose scales are persistent at maturity.

Location: European larch, together with a variety characterized by pendent branchlets (*L. decidua* var. *pendula*) is quite common on campus while there are only two specimens of western larch—one west of Anderson Hall and another in the grove along Campus Parkway.

Cedrus deodara (deodar cedar)

This species is native of the Himalayan area.

Characters: Soft needles and a drooping leader are characteristic of *C. deodara*. As in all true cedars, the cones are barrel-shaped, three to five inches long, and stand erect on the branches until they disintegrate at maturity (in two years).

Location: Most common of the true cedars on campus, they line Stevens Way between the Penthouse Theater and Anderson Hall.

Cedrus atlantica (Atlas cedar) and *C. libani* (Lebanon cedar)

Atlas cedar is native of North Africa, while Lebanon cedar comes from the Near East.

Characters: These two species are difficult to distinguish for both have stiff needles.

Location: Large specimens of *C. atlantica* may be found between Suzzallo Library and the Student Union Building, as well as west of Bloedel Hall. Those in the rear of Lewis Hall are undoubtedly *C. libani*.

Picea

The foliage of many spruces is rigid and prickly to the touch when a branch is firmly grasped. Naked spruce branchlets have a characteristic "warty" appearance, for the small, persistent woody "pegs" upon which the needles grow persist after the foliage has fallen.

Picea sitchensis (Sitka spruce)

Sitka spruce grows on the Pacific coast from Alaska to California, including the rain forest of the deep valleys on the west side of the Olympic Peninsula.

Characters: The needles are flat, up to 1½ inches long and silvery on the underside. They are extremely prickly.

Location: One of the best specimens on campus is south of the parking area east of the University Hospital.

Picea engelmannii (Engelmann spruce)

Engelmann spruce is native in a wide area of the mountainous West, including mid-elevations in the Washington Cascades.

***Pinus monticola,* western white pine.**

Characters: The needles, plump in cross section, are rigid but not noticeably prickly.

Location: Engelmann spruce is represented by but one specimen, planted in the grove along Campus Parkway.

Picea pungens (Blue spruce)

This native of the central Rocky Mountain region is one of the most handsome ornamental conifers.

Characters: Its prickly needles extend in all directions from the branchlets. They are round to four-sided in cross section and usually have a silvery cast.

Location: Commonly planted on campus, it is represented by several fine specimens southwest of Thompson Hall.

Picea abies (Norway spruce)

Norway spruce is native of northern and central Europe.

Characters: Its dark green needles, flattened to triangular in cross section, generally point forward toward the ends of the branchlets. The dark

Picea sitchensis, **Sitka spruce.**

chestnut-brown cones, four to seven inches long, are much darker and longer than the cones of any other species of spruce on campus.

Location: A good specimen is located near the northeast corner of Sieg Hall.

Tsuga

Tsuga heterophylla (western hemlock) and *T. canadensis* (eastern hemlock)

Western hemlock is prevalent in western Washington and elsewhere in the Pacific Northwest, while eastern hemlock is native to southeastern Canada south through the Appalachians. The two species differ only in minor respects.

Characters: Both have flat needles with silvery-white bands on the underside. Less than an inch long, they are of variable length giving the tree a lacy appearance. The oval cones hang from the tips of the branchlets. The central leader at the apex of the crown is weak and gracefully drooping.

Location: Western hemlock is commonly planted on campus, but one of the best and largest specimens can be found north of Guggenheim Hall. Eastern hemlock can be seen in only two specimens—in the grove along Campus Parkway and on the west side of Pend Oreille Road east of McMahon Hall.

Tsuga mertensiana (mountain hemlock)

Characters: The needles, plump or flat in cross section, are not conspicuously variable in length, and they may be densely whorled or curved toward the upper side of the branchlets. Cones vary in length from one to three inches and may be green, amethyst-blue or purple before maturity. The central leader has but a slight droop.

Location: Of the two small specimens on campus, one may be found in the rear of Johnson Hall and the other between Roberts Hall and the Wilson Ceramic Laboratory.

Abies

Abies pinsapo (Spanish fir)

This is the most interesting and the rarest of the true firs on campus.

Characters: Although its rigid needles superficially resemble those of some spruces, as in all true firs they have a broadened base that leaves a conspicuous, round, depressed leaf scar on the branchlets. The cones, also typical of true firs, stand upright on the topmost branches of the crown and disintegrate when mature.

Location: A large specimen grows near the southeast corner of Miller Hall.

Abies concolor (white fir)

White fir is native to mountains from central Oregon to southern California, as well as to the central and southern Rocky Mountain region.

Characters: The needles, two to three inches long and loosely two-ranked on the branchlets, have two silvery bands on the underside.

Location: This is the most common of the true firs on campus and is best represented by a large specimen southwest of Thompson Hall.

The four true firs native to Washington are only sparingly represented on campus, and then only by small specimens:

Abies grandis (grand fir)

Grand fir is a lowland species in the Pacific Northwest.

Characters: Its flat needles of variable length grow in two ranks on either side of the branchlets with the branchlets in plain view, somewhat resembling "hair parted in the middle".

Location: A specimen grows near the northeast corner of Physics Hall.

Abies amabilis (Pacific silver fir)

Characters: The bark is smooth and ash-gray. The flat needles, in addition to extending on either side, lie along the top of the branchlets, obscuring them from view.

Location: One specimen occurs in the Drug Plant Garden.

Abies procera (noble fir)

This handsome tree is native to intermediate

elevations in the Cascades of Washington and Oregon. In its native range, one may see its striking cones, four to six inches long, which are "shingled" by greenish-brown bracts that extend beyond the end of the scales.

Characters: Apart from the cones, which are not produced on campus specimens, the needles are flat to plump, with a silvery tinge. Those of the topmost branches are crowded toward the upper side of the twigs.

Location: A single specimen is planted in the grove along Campus Parkway.

Abies lasiocarpa (subalpine fir)

This species enhances the beauty of high mountain meadows at and just below timberline throughout the Cascades of Washington and Oregon as well as the Rocky Mountain area from Alaska to southern New Mexico.

Location: Small specimens can be found in the grove along Campus Parkway and in the courtyard at the rear of Johnson Hall.

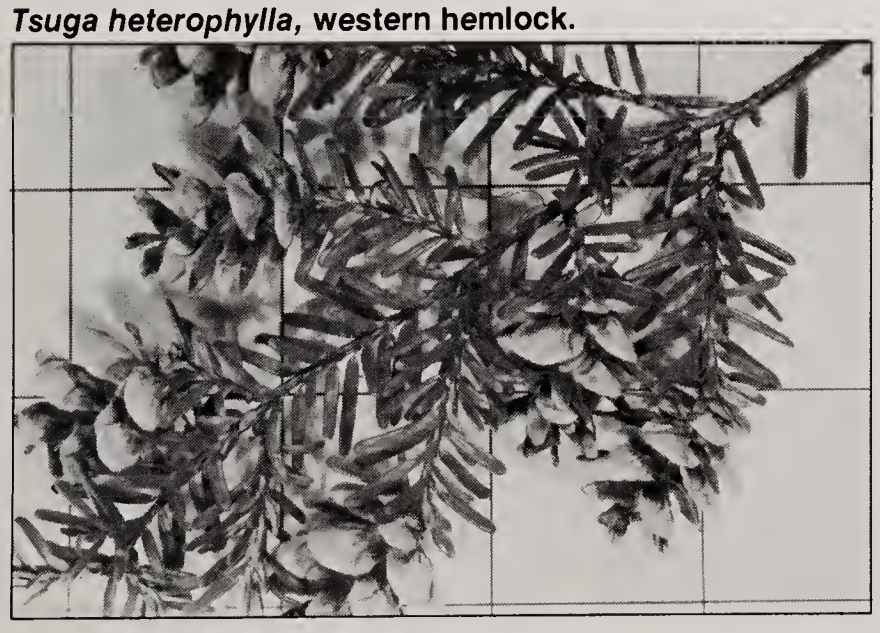
Pseudotsuga

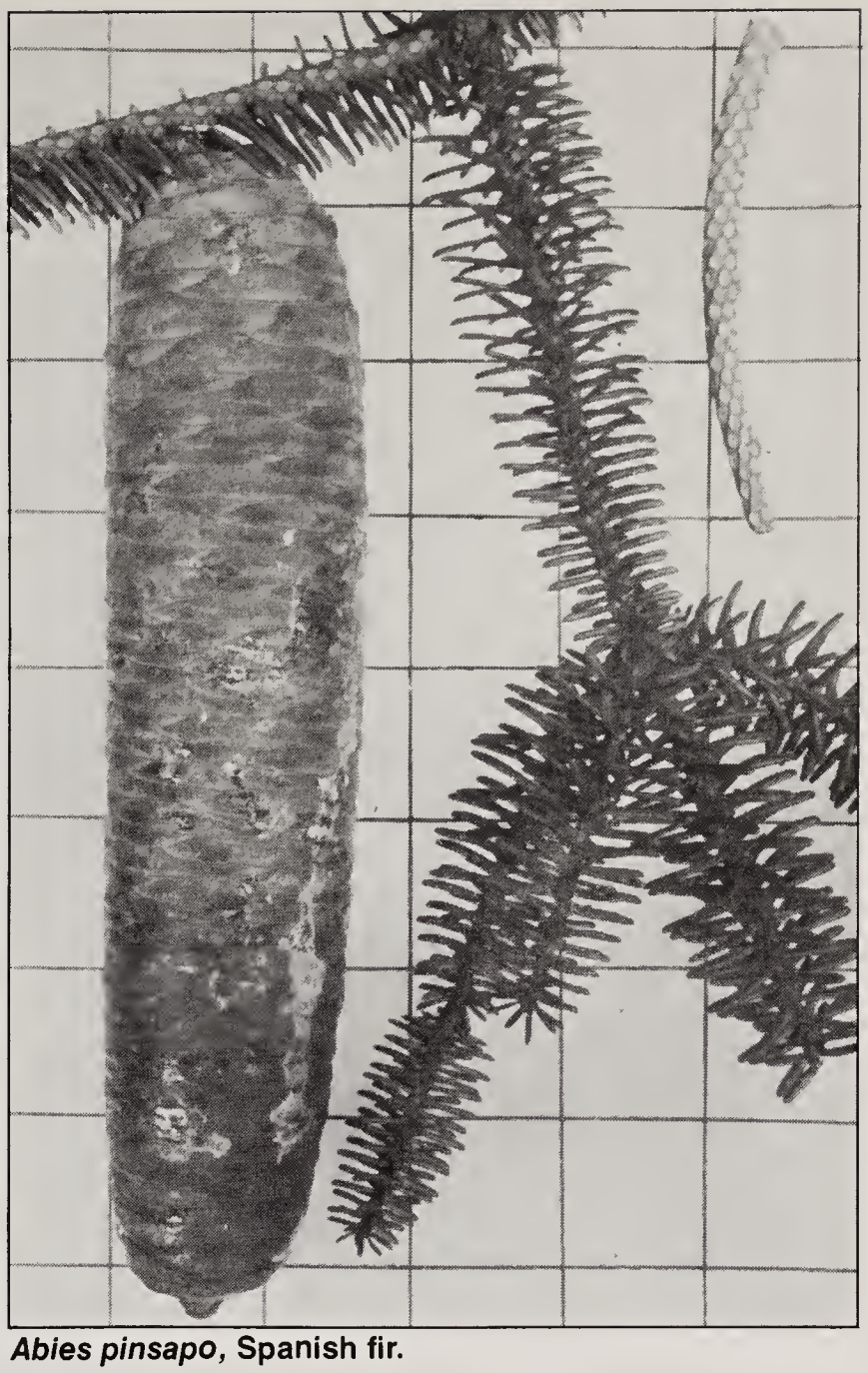
Pseudotsuga menziesii (Douglas fir)

Historically, this tree is very interesting. Its specific scientific name refers to Archibald Menzies, the surgeon and botanist who accompanied Captain George Vancouver on his memorable voyage to Puget Sound in 1792; Menzies first observed the species on the west coast of Vancouver Island during that voyage. The common name honors David Douglas, the Scottish botanist who explored and botanized in many parts of the Pacific Northwest in the early 1800's. The scientific generic name means "false-hemlock", indicative of the confusion that accompanied its eventual proper classification.

Characters: Both needles and cones of Douglas fir are quite dissimilar from those of true firs.

***Tsuga heterophylla*, western hemlock.**





***Abies pinsapo*, Spanish fir.**

The needles are narrowed at the base into a short, slender stem so that leaf scars left on the twigs are minute and slightly raised. The pendent, egg-shaped cones, three to four inches long, have long, three-pointed bracts extending from between the scales, giving them a "feathered" appearance.

Location: Of the numerous Douglas firs of varying sizes, good-sized specimens occur near Kitsap Lane in the grassy area north of Parrington Hall and near Klickitat Lane west of the entrance to Hutchinson Hall.

TAXODIACEAE (THE REDWOOD FAMILY)

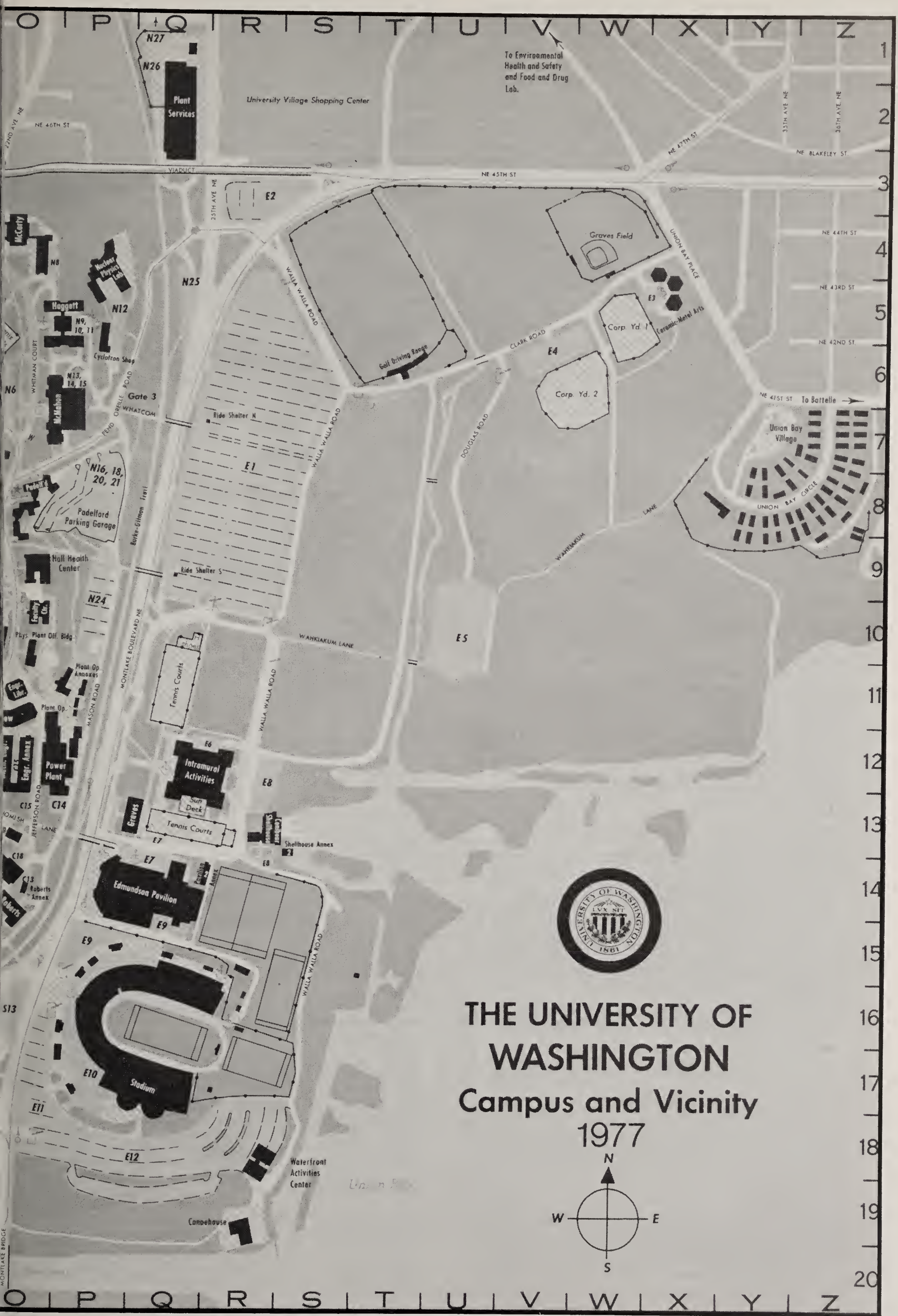
Sequoia sempervirens (redwood)

This species is native to a narow coastal fog belt extending from southwestern Oregon to central California. There it grows to a considerable diameter and great height; exceptional trees have exceeded 350 feet in height and 10 feet in diameter.

Characters: Their dark green, flat, pointed needles have two silvery-white bands on the underside. The oval cones are about one inch

(Continued on p. 26. Please see map of campus and key on pages 22-25.)

KEY TO MAP SYMBOLS
Building
Path/Sidewalk
Road
Campus parking area
Public parking area
Bus route
Bus stop
Automatic parking gate
Campus entrance
Bridge/overpass
Fence
Campus area
Pavement, brick, gravel
Branch library
Wheelchair ramp or access
SCALE
0 300 600 900 Feet
0 91 183 275 Meters
Map compiled, designed, and drafted in cooperation between Physical Plant and the Department of Geography, August 1971
REVISED August, 1977 Sherman
NE 45TH ST
NE 43RD ST
NE 42ND ST
NE 40TH ST
NE PACIFIC ST
NE BOAT ST
NE NORTHLAKE PL
UNIVERSITY BRIDGE
ROOSEVELT WAY NE
11TH AVE NE
12TH AVE NE
BROOKLYN AVE NE
UNIVERSITY WAY NE
15TH AVE NE
17TH AVE NE
18TH AVE NE
19TH AVE NE
21ST AVE NE
MEMORIAL WAY
STEVENS WAY
GEORGE WASHINGTON LANE
COLUMBIA ROAD
SAN JUAN ROAD
Staff Employ. Off.
Univ. Bookstore
U.S. Post Off.
Eagleson
Parrington Annex
VISITOR ENTRANCE
Gate 1
Gate 2
Gate 5
Gate 6
Gate 7
Observatory
Archery Range
Denny Field
Hutchinson
Mercer
Denny
Art
Savery
Miller
Kane
Odegaard Undergrad Library
Suzzallo Library
Mary Gates Hall
Central Plaza Garage
Condon
Schmitz
Hughes Playhouse
VISITOR INFORMATION CTR.
Terry-Lander
Ethnic Cultural Center
Ethnic Cultural Theater
Gould
Staff Svc.
Comm. Duch Apt
Home Mgmt. House
Parking Div.
Architect.
Guthrie
Johnson Annex
Physics
Bagley
Bagley Annexes
Drug Plant Garden
Plant Lab.
Anderson
Winkenwerder Hall
Health Sciences
Health Sci. Annex
University Hospital
Metro Pumping Station
South Campus Parking Garage
South Campus Center
Fisheries Center
Marine Sciences
Ocean. Lab.
Child Development and Mental Retardation Ctr
Salmon Homing Pond
Sakuma Viewpoint
Pacific Apt.
Transp. Services
Computer Center
Northlake Bldg.
Burke-Gilman Trail
Gate 7


THE UNIVERSITY OF
WASHINGTON
Campus and Vicinity
1977
N
W
E
S
Plant Services
University Village Shopping Center
To Environmental Health and Safety and Food and Drug Lab.
NE 46TH ST
VIADUCT
NE 45TH ST
NE 47TH ST
NE BLAKELEY ST
NE 44TH ST
NE 43RD ST
NE 42ND ST
NE 41ST ST
To Battelle
Graves Field
UNION BAY PLACE
Corp. Yd. 1
Ceramic-Metal Arts
Corp. Yd. 2
Golf Driving Range
CLARK ROAD
WALLA WALLA ROAD
DOUGLAS ROAD
WAHKIAKUM LANE
Union Bay Village
UNION BAY CIRCLE
McCarty
Haggett
Cyclotron Shop
Gate 3
WHITMAN COURT
PEND OREILLE ROAD
WHATCOM
Ride Shelter N
Ride Shelter S
Padelford Parking Garage
Burke-Gilman Trail
Hall Health Center
Phys. Plant Off. Bldg
Plant Op. Annexes
Plant Op.
MONTLAKE BOULEVARD NE
MASON ROAD
Tennis Courts
Intramural Activities
Sun Deck
Graves
Shellhouse Annex
Edmundson Pavilion
Stadium
Waterfront Activities Center
Canoehouse
Power Plant
Engr. Annex
JEFFERSON ROAD
Roberts Annex
MONTLAKE BRIDGE

Administration Building (ADM) 10–K
Admissions, Schmitz Hall 9–I
Aerodynamics Laboratory 11–N
Aeronautics and Astronautics, Guggenheim Hall. 11–N
Aerospace and Engineering Research Laboratory (AER) 12–N
Aerospace Studies, Clark Hall 7–O
Alumni Office, 1415 N.E. 45th Street 3–I
Anderson Hall (AND) 14–M
Anthropology, Denny Hall 6–L
Applied Physics Laboratory, 1013 N.E. 40th Street 10–F
Arboretum, over Montlake Bridge to Washington Park
Archery Range 4–L
Architecture, Gould Hall 11–I
Architecture and Urban Planning Library, Gould Hall 11–I
Architecture Hall (ARC) 11–J
Art, Art Building (ART) 6–M
Art Library, Art Building 6–M
Arts and Sciences, Padelford Hall 8–O
Asian Languages and Literature, Gowen Hall. 9–M
Associated Students (ASUW), Student Union Building (HUB) . 10–N
Astronomy, Physics Hall 11–L
Astronomy-Physics Library, Physics Hall 11–L
Atmospheric Sciences,
Atmospheric Sciences–Geophysics Building (ATG) 12–K
Attorney General's Division, Administration Building 10–K

Bagley Annexes 1, 2, 3 & 4 . . . . . 13–L
Bagley Hall (BAG) 12–L
Balmer Hall (BLM) 5–M
Benson Hall (BNS) 13–K
Bioengineering, Aerospace Research Laboratory. 12–N
Biological Sciences Wing, Health Sciences Building. 15–K
Bloedel Hall (BLD) 15–M
Book Store, 4326 University Way N.E.. . . . . 4–I
Branch, Student Union Building (HUB) 10–N
Branch, South Campus Center 17–J
Botany, Johnson Hall. 11–L
Botany Greenhouse (BGH) 14–K
Building Construction, Gould Hall. 11–I
Burke Memorial Washington State Museum (BMM) 4–J
Business Administration, Mackenzie Hall 6–M
Business Administration Library, Balmer Hall 5–M
Business and Finance, Administration Building 10–K

Campanile 9–K
Cancer-Primate Wing, Health Sciences Building 15–K
Canoehouse (CNH) 19–R
Cashier's Office, Schmitz Hall 9–I
Center for Studies in Demography and Ecology, Savery Hall . 8–L
Central Plaza Garage, Central Plaza. 9–K
Central Stores, Plant Services Building. 2–Q
Ceramic and Metal Arts Facility (CMA) 5–X
Ceramic Engineering, Roberts Hall 14–O
Chemical Engineering, Benson Hall. 13–K
Chemistry, Bagley Hall. 12–L
Chemistry-Pharmacy Library, Bagley Hall 12–L
Child Development and Mental Retardation Center (CDC). . . 19–M
Civil Engineering, More Hall. 14–O
Clark Hall (CLK) 7–O
Classics, Denny Hall 6–L
Columns and Sylvan Theater 13–N
Commodore-Duchess Apartments, 4009-15th Ave. N.E. 10–I
Commons Dining Room, Raitt Hall 7–M
Communications, Communications Building (CMU) 8–N
Community and Organization Development,
Lewis Hall 6–N
Comparative Literature, Padelford Hall 8–O
Comptroller, Administration Building. 10–K
Computer Center, 3737 Brooklyn Ave. N.E. (CCR) 13–G
Condon Hall (CDH), 1100 Campus Parkway N.E. 8–F
Conibear Shellhouse (CSH) 13–R
Continuing Education, Lewis Hall 6–N
Copy Centers:
B40 Administration Building 10–K
115 Balmer Hall 5–M
B3 Communications Building. 8–N
D252 & E210 Health Sciences. 15–K
Odegaard Library, 1st Floor 9–K
18 Schmitz Hall 9–I
450 Suzzallo Library. 10–L
EE112 University Hospital 17–M
Counseling Center, Schmitz Hall 9–I
Cyclotron, Nuclear Physics Laboratory 5–P
Cyclotron Shop, Nuclear Physics Laboratory 5–P

Denny Hall (DEN). 6–L
Dentistry, Health Sciences Building 15–K
Drama, Drama-TV Building (DTV) 12–K
Drama Annex, 1101 N.E. Boat Street (DRX). 14–F
Drama Library, Drama-TV Building 12–K
Drama Scene Shop, 3941 University Way N.E. (DSC). 10–H
Drug Plant Garden and Laboratory 14–L
Drumheller Fountain 12–M

Eagleson Hall, 1417 N.E. 42nd Street (EGL) 7–I
East Asia Library, Gowen Hall 9–M
Economic Research Institute, Savery Hall 8–L
Economics, Savery Hall 8–L
Edmundson Pavilion (EDP) 14–Q
Education, Miller Hall 8–N
Educational Television KCTS-TV, Drama-TV Building 12–K
Electrical Engineering, Electrical Engineering Building (EEB) 13–N
Engineering, Loew Hall 11–O
Engineering Annex (EGA) 12–O
Engineering Library, Engineering Library Building 11–O
Engineering Research, Loew Hall 11–O
English, Padelford Hall. 8–O
Environmental Health and Safety, 4725 30th Avenue N.E. . . off map
Ethnic Cultural Center, 3931 Brooklyn Avenue N.E. (ECC). . . 10–H
Ethnic Cultural Theater, 3940 Brooklyn Avenue N.E.. . . . . 10–H
Evening and Extension Credit Programs,
Lewis Hall 6–N

Facilities Planning and Construction
Administration Building. 10–K
Faculty Center 10–O
Fisheries, Fisheries Center (FIS) 18–K
Fisheries-Oceanography Library,
Oceanography Teaching Building. 16–I
Fisheries Research Institute, Fisheries Center 18–K
Fisheries, Washington State Department, Fisheries Center 18–K
Flag Pole 8–K
Food and Drug Laboratory, Washington State,
2900 N.E. Blakeley Street . . . . . off map
Food Service Facilities:
Commons Dining Room, Raitt Hall 7–M
Health Sciences Snack Bar 15–K
Hospital Cafeteria 17–M
Odegaard Undergraduate Library Cafeteria 9–K
South Campus Center 17–J
Student Union Building Evergreen Room and Husky Den . 10–N
Forest Products Institute, Anderson Hall 14–M
Forest Resources, Anderson Hall 14–M
Forest Resources Library, Bloedel Hall 15–M
Friday Harbor Laboratories, Kincaid Hall 13–J

Genetics, Health Sciences Building 15–K
Geography, Smith Hall 9–M
Geography Library, Smith Hall 9–M
Geological Sciences, Johnson Hall 11–L
Geophysics, Atmospheric Sciences–Geophysics Building . . . 12–K
Germanics, Denny Hall. 6–L
Golf Driving Range (GDR) 6–T
Gould Hall (GLD), 3949 15th Ave. N.E.. . . . . 11–I
Gowen Hall (GWN) 9–M
Graduate School, Administration Building 10–K
Graves Building (TGB) 13–Q
Guggenheim Hall (GUG) 11–N
Guthrie Annexes 1 and 2 (GA1 and GA2) 12–J, 11–J
Guthrie Hall (GTH) 12–J

Haggett Hall 5–P
Hall Health Center 9–O
Hansee Hall. 3–M
Harris Hydraulics Laboratory (HHL). 17–J
Health Sciences Annexes 1, 2, and 3 . . . . . .16–K, 17–M
Health Sciences Building (HSB). 15–K
Health Sciences Library, Health Sciences Building 15–K
Henry Art Gallery (HAG) 9–J
High-Energy Physics Laboratory (HEP) 10–M
History, Smith Hall 9–M
Home Economics, Raitt Hall 7–M
Home Management House (HMH). 11–J
Hospital (UWH) 17–M
Hughes Playhouse (HPH)
4045 University Way N.E. 8–H
Humanistic-Social Studies for Engineers, Loew Hall. 11–O
Hutchinson Hall (HUT). 5–M

Infirmary, Hall Health Center 9–O
Institute for Comparative and Foreign Area Studies,
Thomson Hall 9–N
Institute of Governmental Research, 3935 University Way N.E. 11–H
Instructional Media Services, Kane Hall 9–L
Intercollegiate Athletics, Graves Building 13–Q
International Pacific Halibut Commission,
Oceanography Teaching Building 16–I
International Services Office, Schmitz Hall 9–I
Intramural Activities Building (IMA) 12–Q

Johnson Annex A (JHA). 11–K
Johnson Annex B (JHB) 11–K
Johnson Hall (JHN). 11–L

Kane Hall (KNE) 9–L
KCTS-TV, Drama-TV Building 12–K

Keep Washington Green Association, Anderson Hall 14–M
Kincaid Hall (KIN) 13–J
Kirsten Aeronautical Laboratory. 11–N
KUOW Radio, Communications Building 8–N

Lander Hall, 1201 N.E. Campus Parkway 10–G
Landscape Architecture, Gould Hall. 11–I
Language Learning Center, Denny Hall 6–L
Law, Condon Hall. 8–F
Law Library, Condon Hall 8–F
Lectures and Concerts, Meany Hall 10–J
Lewis Annex (LWA) 6–N
Lewis Hall (LEW) 6–N
Librarianship, Suzzallo Library 10–L
Linguistics, Padelford Hall. 8–O
Loew Hall (LOW) 11–O

Mackenzie Hall (MKZ) 6–M
Mail Services, 3755 University Way N.E. 13–H
Marine Sciences Building (MSB) 17–I
Marine Resources, 3716 Brooklyn Avenue N.E.. . . . . 14–H
Mathematics, Padelford Hall 8–O
Mathematics Research Library, Padelford Hall. 8–O
McCarty Hall 4–O
McMahon Hall 7–O
Meany Hall (MNY) 10–J
Mechanical Engineering, Mechanical Engineering
Building (MEB). 12–O
Medicine, Health Sciences Building 15–K
Memorial Way. 3–K
Mercer Hall 11–F
Military Sciences, Savery Hall 8–L
Miller Hall (MLR) 8–N
Mining, Metallurgical, and Ceramic Engineering,
Roberts Hall 14–O
Minority Affairs, Schmitz Hall 9–I
More Hall (MOR) 14–O
Music, Music Building (MUS) 7–N
Music Library, Music Building. 7–N

Naval Sciences, Clark Hall 7–O
Near Eastern Languages and Literature, Denny Hall. 6–L
Northlake Building, 814 N.E. Northlake Place 10–D
Nuclear Engineering, Benson Hall 13–K
Nuclear Physics Laboratory (NPL). 5–P
Nuclear Reactor Building (NRB). 13–O
Nursing, Health Sciences Building 15–K

Observatory (OBS) 4–K
Oceanography, Oceanography Teaching Building (OTB). . . . 16–I
Oceanography Barge (OCB) 18–J
Oceanography Building 18–K
Oceanography-Fisheries Library,
Oceanography Teaching Building. 16–I
Odegaard Undergraduate Library (OUG) 9–K
Office Machine Maintenance Shop, 3733 12th Avenue N.E. . . 13–G
Ombudsman, Student Union Building 10–N

Pacific Apartments, 3748–60 University Way N.E. 13–I
Padelford Hall (PDL) 8–O
Padelford Parking Garage 8–P
Parking Division Building 11–J
Parrington Annexes 1, 2 and 3 (PR1, 2 & 3) 7–K, 8–K
Parrington Annex 4, 4115 15th Avenue N.E. (PR-4). 8–I
Parrington Annex 7, 4131 15th Avenue N.E. (PR-7). 7–I
Parrington Hall (PAR) 8–K
Parrington Greenhouse 8–K
Pavilion Annex 2 . . . . . 14–R
Penthouse Theater (PTH) 13–J
Pharmacy, Bagley Hall 12–L
Pharmacy-Chemistry Library, Bagley Hall 12–L
Philosophy, Parrington Hall 8–K
Philosophy Library, Savery Hall 8–L
Physical and Health Education,
Hutchinson Hall 5–M
Physical Plant Office Building. 10–O
Physics, Physics Hall (PHY) 11–L
Physics-Astronomy Library, Physics Hall 11–L
Placement Center, Loew Hall 11–O
Plant Laboratory (PLT) 14–K
Plant Operations Building 11–O
Plant Services Building, 4515 25th Avenue N.E. 2–Q
Political Science, Gowen Hall 9–M
Political Science Library, Smith Hall 9–M
Post Office, U.S., 4244 University Way N.E.. . . . . 5–I
Postal Substation, Student Union Building (HUB) 10–N
Power Plant 12–O
Practice Field 14–R, 11–R
President's Office, Administration Building 10–K
Printing, Communications Building. 8–N
Psychology, Guthrie Hall. 12–J
Public Affairs, Smith Hall 9–M
Public Health and Community Medicine,
Health Sciences Building 15–K

Publications, Communications Building 8–N
Purchasing and Accounting Office Building,
3917 University Way N.E. 11–H

Quadrangle 8–M
Quaternary Research Center,
Atmospheric Sciences–Geophysics Building. 11–K

Radiation Ecology Laboratory, Fisheries Center 18–K
Radio Broadcast Services and KUOW,
Communications Building. 8–N
Rainier Vista 15–N
Raitt Hall (RAI) 7–M
Regents, Board of, Administration Building 10–K
Registrar, Schmitz Hall 9–I
Retirement and Insurance Office, Staff Services Building. . . 11–G
Roberts Annex 14–O
Roberts Hall (ROB) 14–O
Romance Languages and Literature, Padelford Hall 8–O
ROTC, Aerospace Studies, Clark Hall 7–O
ROTC, Military Sciences, Savery Hall 8–L
ROTC, Naval Sciences, Clark Hall 7–O

Salmon Homing Pond 19–K
Savery Hall (SAV). 8–L
Scandinavian Languages and Literature, Padelford Hall . . . 8–O

Schmitz Hall, 1410 N.E. Campus Parkway 9–I
Shellhouse Annex 2 . . . . . 13–S
Short Courses and Conferences, Lewis Hall 6–N
Showboat Theater (SHB). 18–J
Sieg Hall (SIG) 11–M
Slavic Languages and Literature, Thomson Hall 9–N
Smith Hall (SMI) 9–M
Social Work, Eagleson Hall 7–I
Social Work Library, Eagleson Hall 7–I
Sociological Research, Savery Hall 8–L
Sociology, Savery Hall 8–L
South Campus Center 17–J
South Campus Parking Garage 17–K
Speech Communication, Parrington Hall 8–K
Speech and Hearing Clinic,
1320 N.E. Campus Parkway (SPC) 9–H
Stadium. 16–Q
Staff Employment Office, 1415 N.E. 45th Street 3–I
Staff Services Building, 3903 Brooklyn Avenue N.E. 11–G
Student Affairs, Schmitz Hall 9–I
Student Employment Office, Schmitz Hall 9–I
Student Financial Aids Office, Schmitz Hall 9–I
Student Health Center, Hall Health Center 9–O
Student Housing Office, Schmitz Hall 9–I
Student Union Building (HUB) 10–N
Summer Quarter Office, Lewis Hall 6–N
Suzzallo Library (SUZ) 10–L
Swimming Pools:
Edmundson Pavilion. 14–Q
Hutchinson Hall 5–M
Intramural Activities Building 12–Q

Telecourses, Lewis Hall 6–N
Television KCTS-TV, Drama-TV Building 12–K
Tennis Courts 5–N, 11–Q, 13–Q
Terry Hall, 1101 N.E. Campus Parkway 10–G
Testing, Schmitz Hall 9–I
Thomson Hall (THO) 9–N
Toxicology Laboratory, State, Health Sciences Building. . . . 15–K
Transportation Services 14–J

Undergraduate Studies, Padelford Hall 8–O
Union Bay Village 8–Y
University Hospital (UWH). 17–M
University Police, 1117 N.E. Boat Street 14–F
University Press, 4045 Brooklyn Avenue N.E.. . . . . 8–H
University Relations and Oevelopment,
Administration Building. 10–K
Urban Planning, Gould Hall 11–I

Veterans Affairs, Schmitz Hall. 9–I
Visitor Entrance 8–J
Visitors Information Center, 4014 University Way N.E. 10–I

Washington Monument (Statue). 9–J
Waterfront Activities Center 19–R
Wilson Ceramic Laboratory (WCL). 15–O
Winkenwerder Hall (WFS) 15–M

Zoology, Kincaid Hall. 13–J

Additional copies of this map are available from Central Stores. Contact the University of Washington Office of Publications for information concerning the production of this map or the Department of Geography for information concerning its contents.

(ADM) indicates building abbreviation used on official programs.

***Sequoia sempervirens*, redwood.**

(Continued from page 21.)

long with flat-topped scales. The fibrous bark is reddish brown.

Location: Good specimens are located near Stevens Way between the Art Building and Mackenzie Hall, as well as on the northeast corner of Anderson Hall.

Sequoiadendron giganteum (giant sequoia)

Giant sequoia is native to groves at elevations between 4000 and 8000 feet on the west side of the Sierra Nevada in central and southern California. There, numerous specimens of great age and size are considered to be among the largest of living things.

Characters: Foliage is characterized by blue-green, closely overlapping, awl-like scales with straight tips. The cones, which are rarely seen on campus specimens, resemble those of redwood, except for their larger size. The reddish brown bark, like that of redwood, is fibrous.

Location: Good-sized trees can be found near the northeast corner of Smith Hall and also on the north side of Stevens Way opposite the entrance to Anderson Hall; a group of three smaller ones occupies the grassy triangle between Suzzallo Library and Gowan Hall.

Cryptomeria japonica (Japanese cedar)

This species is often mistaken for giant sequoia because of its somewhat similar awl-like foliage.

Characters: The foliage is darker green than that of *Sequoiadendron* and the pointed tips of the scales curve inward. Oval cones, about one inch long, have bristly projections on the scales.

Location: The one good specimen grows near Parking Area E-12 south of the stadium

Metasequoia glyptostroboides (dawn redwood)

This "fossil" tree was considered to be extinct until living specimens were discovered in a remote valley in China in the 1940's.

Characters: The deciduous branchlets have two-ranked, flat needles.

Location: A fine specimen is located between Guggenheim and Sieg Halls.

Cunninghamia laceolata (China fir)

Characters: This native of China has rigid, lance-shaped needles, one to two inches long, which taper to a sharp point. They are green above with two silvery-white bands on the underside.

Location: China fir is found in the grove along Campus Parkway and near the buildings of the College of Forest Resources.

Sciadopitys verticillata (Japanese umbrella pine)

Characters: This tree has two kinds of foliage. The main branches are covered by narrow elongated scales, while branch spurs bear distinctive whorls of 8 to 25 needles resembling the expanded ribs of an umbrella. They are three to six inches long, dark green on the upper side, with two silvery-white bands below.

Location: A small specimen may be found in the Drug Plant Garden.

Taxodium distichum (bald cypress)

It is a common species in swamplands in the southeastern United States.

Characters: This deciduous tree has flat needles up to ¾ of an inch long. They are yellow-green and two-ranked on lateral branchlets, turning brown before the branchlets are shed in autumn. There is also scale-like foliage on the fertile branches.

Location: One specimen grows south of the Plant Services Building. Although it is in an unhandy place, it is well worth the walk to see it.

CUPRESSACEAE (THE CYPRESS FAMILY)

Thuja

Thuja plicata (western red cedar)

This native of the Pacific Coast and the northern Rocky Mountain region served the Northwest Indians in many ways, as is indicated by exhibits in the Burke Museum.

Characters: Western red cedar has lustrous, dark green, closely overlapping scale-like foliage, the scales about ¼ inch long, arranged in alternate pairs on the branches. The oblong cones are about ½ inch long. The dark brown bark is fibrous and vertically ridged.

Location: It is quite common on campus; fine specimens may be found northwest of the main entrance to the Student Union Building and in the grassy area west of Roberts Hall.

Thuja occidentalis (nothern white cedar)

This native of southeastern Canada south through the Appalachians is somewhat similar to western red cedar, though it is smaller and less impressive.

Characters: The scale-like foliage is yellow-green.

Location: Typical specimens may be found near the Home Management House and west of Anderson Hall.

Thuja orientalis (Oriental arborvitae)

Characters: The foliage is typically scale-like, but the cones are larger, ½ to 1 inch long, with scales ending in horn-like projections.

Location: A specimen may be found in the grove along Campus Parkway.

Calocedrus

Calocedrus decurrens (incense cedar)

This species is indigenous to the Pacific Coast from central Oregon to Baja California.

Characters: The lustrous, dark green foliage has overlapping scales in whorls of four.

Location: Specimens grow on the south side of Suzzallo Library and bordering the roadway west of Anderson Hall.

Chamaecyparis

Chamaecyparis lawsoniana (Port Orford cedar)

Port Orford cedar is native to southwest Oregon and northwest California.

Characters: The small scales, up to ¼ inch long, closely overlap in alternate pairs, with margins on the underside marked with white crosses. The cones, usually produced in abundance, are globular, a bit more than ¼ inch in diameter, with wedge-shaped, flat-topped scales that have a small curved point in the center. This is an extremely variable tree.

Location: Typical specimens and a number of varieties are planted on campus. Good specimens may be seen northwest of Johnson Hall and on several corners of Guggenheim Hall.

Chamaecyparis nootkatensis (Alaska cedar)

Alaska cedar grows at mid-elevations in the Cascades of Washington and Oregon, as well as at progressively lower elevations as it ranges north to coastal Alaska.

Characters: The foliage and cones resemble those of Port Orford cedar, but its most striking feature is the noticeably pendent branches, which often give it a wilted appearance.

Location: A good specimen may be found north of Sieg Hall.

Cupressus

Cupressus sempervirens (Italian cypress)

Characters: Italian cypress also has scale-like foliage and globular cones, but the latter are 1 to

***Chamaecyparis lawsoniana*, Port Orford cedar.**

1½ inches in diameter, and the short branches form a columnar crown.

Location: This species may be found along the walkway between the Student Union Building and Suzzallo Library.

Juniperus

Juniperus virginiana (eastern red cedar) and *Juniperus scopulorum* (Rocky Mountain juniper).

Eastern red cedar is native to the eastern United States; Rocky Mountain juniper occurs on dry soils throughout a wide area in the western United States, including dry, rocky locations in the Puget Sound region.

Characters: These species often have two kinds of foliage: it is scale-like on old growth but awl-like, pointed and somewhat prickly on new growth near the ends of many branches. The cones are basically similar; often called juniper berries, they are globular, about ¼ inch in diameter and somewhat fleshy, with poorly defined scales lightly covered by gray wax.

Location: Junipers may be found in the Drug Plant Garden as well as around the High Energy Physics Laboratory.

ARAUCARIACEAE

Araucaria araucana (monkey puzzle)

This bizarre tree is native of Chile.

Characters: The species is typified by an open crown with whorls of long, horizontal to pendulous branches, which are covered by stiff, leathery, sharp-pointed, loosely-overlapping scales up to two inches long.

Location: Several trees may be found east of Denny Hall.

TAXACEAE (THE YEW FAMILY)

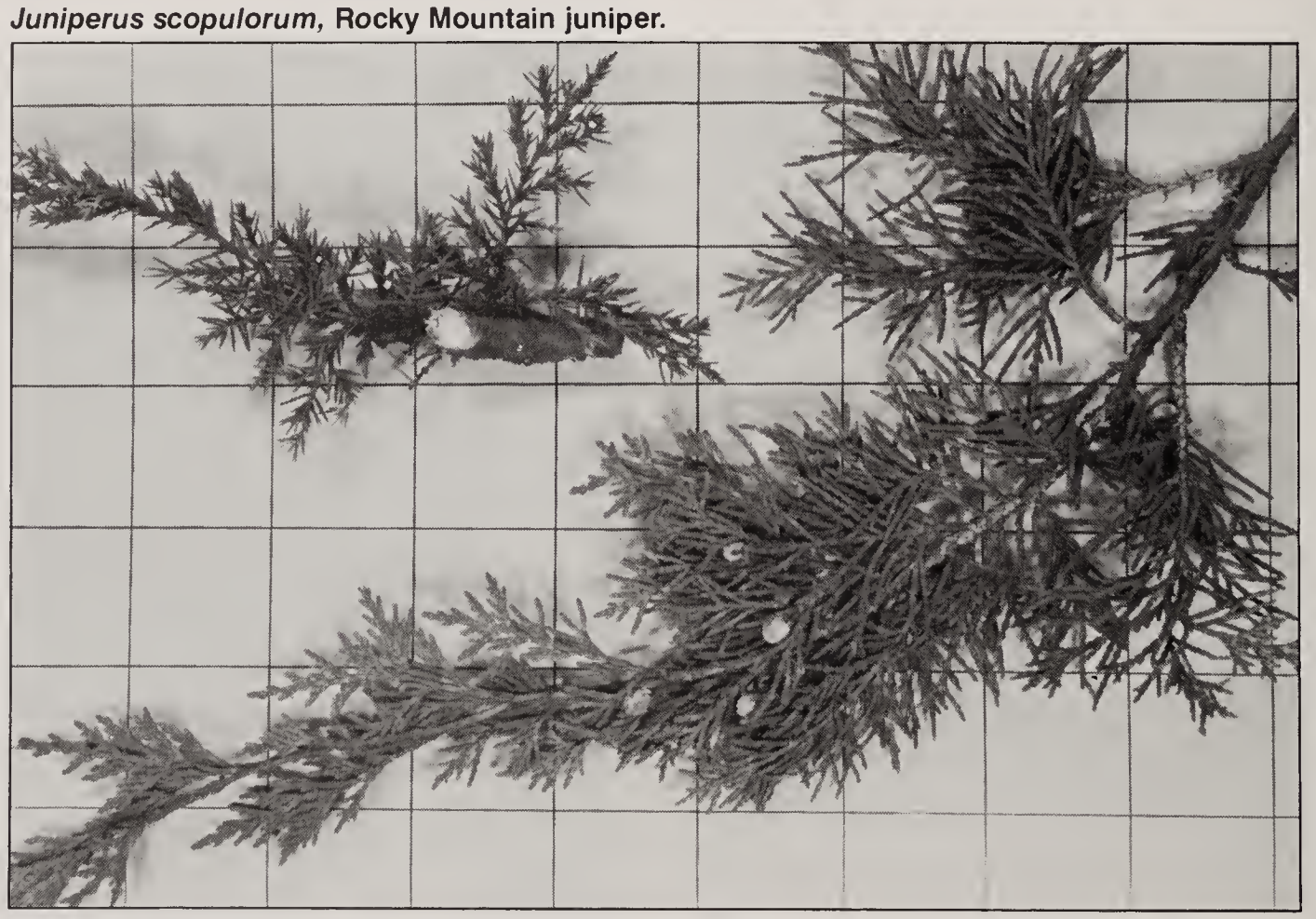
Taxus baccata (English yew)

This native of Europe is related to Pacific yew (*Taxus brevifolia*), which, unfortunately, is not represented on campus.

Characters: This is one of several gymnosperms that do not produce cones; the seeds are borne singly and are partly enclosed by a bright red, gelatinous cup or aril. The flat, pointed needles are dark green above and light green below. It is a species with many varieties.

Location: Specimens in the Drug Plant Garden have a distinctive columnar crown of short branches.

Juniperus scopulorum, **Rocky Mountain juniper.**



Self-Incompatibility In Flowering Plants

*ADOLPH HECHT**

Most of the species of flowering plants have both sexes in a single individual, and most of these have both stamens and pistils in the same flower; such flowers are termed "perfect". Plants having separate staminate (male) and pistillate (female) flowers, but with both on the same individual plant, are termed "monoecious". Plants with perfect flowers and those with both types of imperfect flowers on the same individual (monoecious plants) are hermaphrodites, a condition necessarily more important for plants than for animals because lacking the locomotor powers of most animals, a single female-only plant of a non-hermaphroditic species must depend upon some external agency (usually an insect or the wind) to transfer to it the male element contained in pollen. If there are no staminate plants nearby, the isolated pistillate plant is unable to reproduce by sexual means. But as indicated above, this problem does not exist for most species of flowering plants because their flowers are perfect, or the plants, such as *Begonia* and corn (*Zea*), are monoecious in that they bear both staminate and pistillate flowers on a single individual.

For plants as well as for animals, inbreeding, which is the mating of closely related individuals, is generally considered less desirable than outbreeding. The mixture of genetic information which normally will occur as a result of outbreeding usually results in stronger, better adapted progeny, whereas inbreeding may result in the expression of lethal and sublethal genes, for example, hemophilia in man, that are normally masked as a result of outbreeding.

Despite the obvious advantage of hermaphroditism for individual plants which may be growing in isolated spots, hermaphroditism ordinarily favors inbreeding. Toward minimizing the extent of inbreeding many species have developed means that either effectively reduce the degree to which a single plant can be self-pollinated, or almost entirely prevent the setting of seeds through self-pollination. By self-pollination we mean, of course, that the pollen has come from either the same flower as the stigma or from another flower of the same individual plant or clone.

Ripening of the stamens and stigmas of an individual flower at different times (dichogamy), or the location of the stamens either well above or well below the level of the stigmas (heterostyly) effectively reduces the possibility or at least the frequency of self-pollination. Even more effective means for reducing or eliminating inbreeding, which usually results from self-pollination, are two genetic phenomena that do not alter the appearance of the floral parts. One of these is the occurrence of balanced lethal genes, a situation prevalent, for example, in many of the species of the evening primrose (*Oenothera*). These plants have outbred and will continue to outbreed because their balanced lethal genes either prevent the formation of non-hybrid progeny, or prevent the survival of other than hybrid progeny at an early stage of their development. The other genetic phenomenon, self incompatibility, will be the principal topic of this article.

Many varieties of our commercial tree fruits (sweet cherries, plums, apples, pears, etcetera) are self-incompatible in that they fail to set fruit if grown in pure stands of a single variety. Early in this century large orchards of single varieties were planted, and only later when the trees began to reach maturity was it realized that few if any fruits were being set. The many individual trees of each variety were really a single individual that had been propagated vegetatively, hence a clone. Although each of the trees produced both pollen and ovules, the male elements from the pollen failed to reach the female cells in the ovules because of the failure of the pollen tubes to grow through the stigmas and styles of the pistils. Only by interplanting these orchards with some trees of another variety, which would produce pollen that would grow through the stigmatic/stylar tissues, could an adequate set of fruits be obtained. Reliable fruit-tree nursery companies now advise their customers concerning which varieties need

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pollinator trees and which are the best combinations for the maximum setting of fruits.

Self-incompatibility in the flowering plants involves mechanisms that prevent pollen tubes produced by an individual plant from reaching the ovaries of flowers of the same individual. In some instances the pollen grains are effectively prevented from germinating, or if they do begin to germinate their tubes only barely penetrate the tissues of the stigma. In other cases the pollen tubes enter the tissues of the stigmas but do not reach the styles, and in still other plants the pollen tubes grow too slowly through the stylar tissues to reach the ovules during the functional life of the flower.

The most widely supported explanation of self-incompatibility is based upon an interaction of substances, possibly proteins, produced by the stigmatic and stylar tissues on the one hand, and by the pollen tubes on the other. If the same (or complementary) substances are present in the pollen tubes as are present in the tissues through which the pollen tubes begin growing, some sort of inhibitory action on the continued growth of these pollen tubes takes place. Self-incompatibility has been compared to immune reactions in man and other animals, but whereas identical substances lead to rejection in the case of self-incompatibility, they are necessary in order to prevent rejection in the case of immune reactions in animals.

The history of our knowledge about self-incompatibility in plants (earlier called self-sterility) has been well documented by de Nettancourt (1977). Earlier workers thought that each individual plant exhibiting what we now call self-incompatibility would be fertile if pollinated by any other individual of the same species, but it was soon discovered that there were groups of individual plants within the species which were inter-incompatible. Knowledge emerged by the early 1920's about a definite pattern of genetic factors controlling incompatibility.

It is general knowledge that each pollen grain carries only one of each pair of chromosomes present in the plant that produced it. In the simplest (and probably most common) cases of self-incompatibility, one of the chromosome pairs of the parent plant bears two different genes controlling self-incompatibility, one on each member

Figure 1. Diagram shows the pistil and one stamen of a self-incompatible plant of genetic constitution S_1S_2. Both of the types of pollen grains, designated as 1 and 2, produced by this plant grow pollen tubes that are inhibited either in the stigma or in the upper parts of the style, and hence fail to reach the ovules. Pollen grains with S_3 and S_4 genes (cross-pollinated from a S_3S_4 plant) are also shown on the S_1S_2 stigma, and as shown, these produce pollen tubes that are uninhibited, grow all the way to ovules, which can then be fertilized to produce seeds. In Figure 2, the reverse situation is shown, when the self-incompatible plant is S_3S_4 and only S_1S_2 pollen tubes reach the ovules.

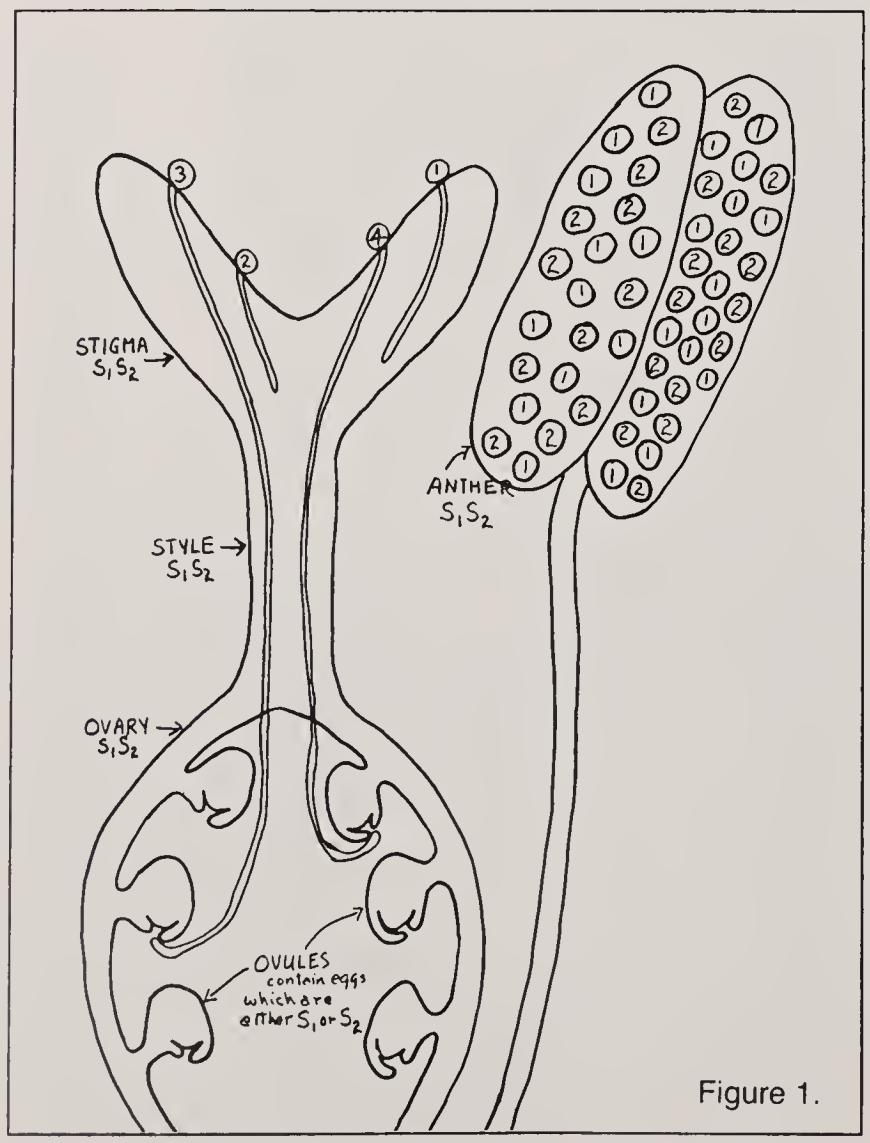


Figure 1.

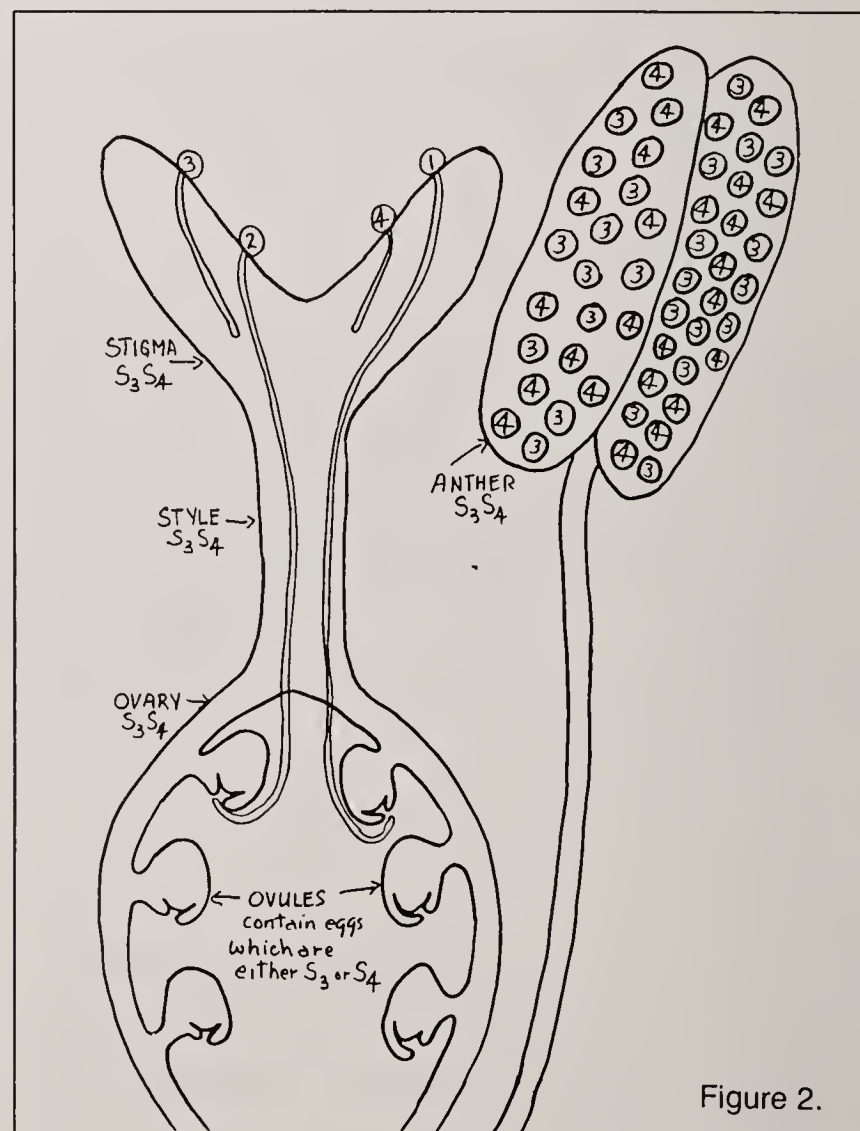


Figure 2.

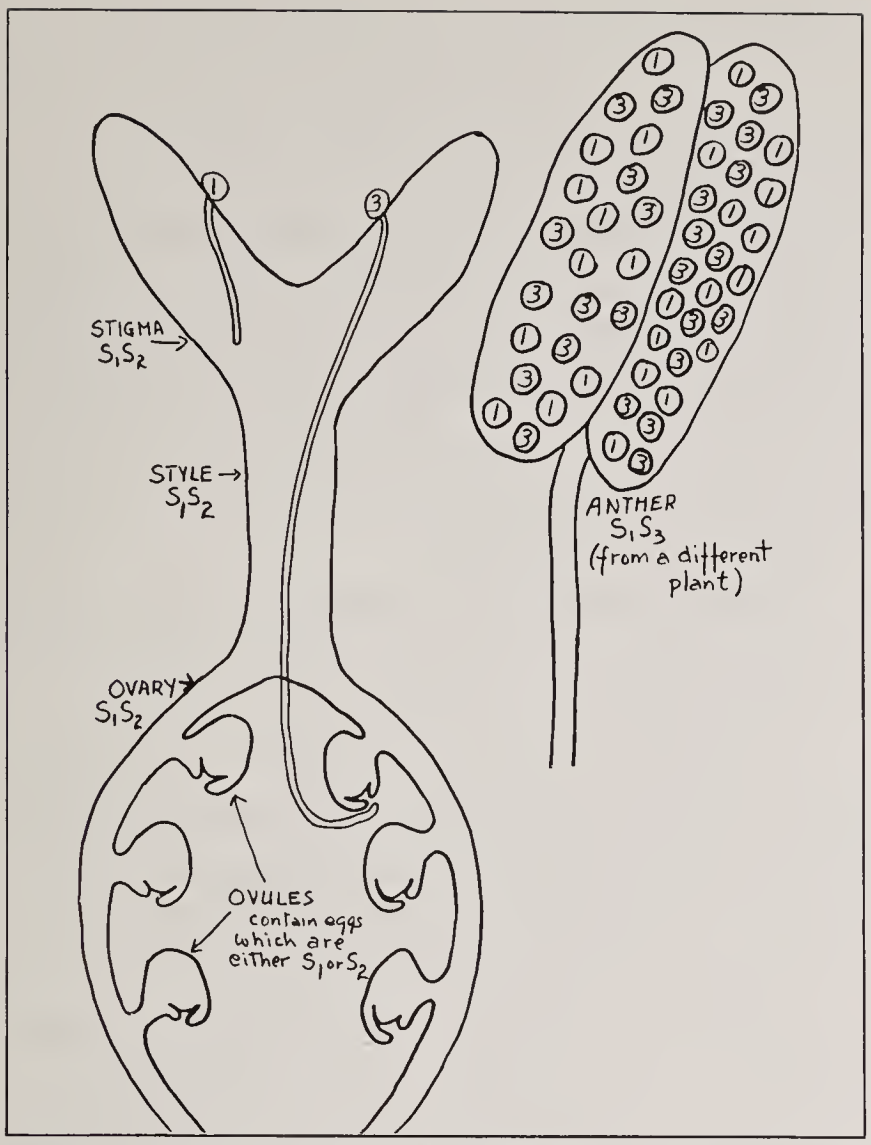


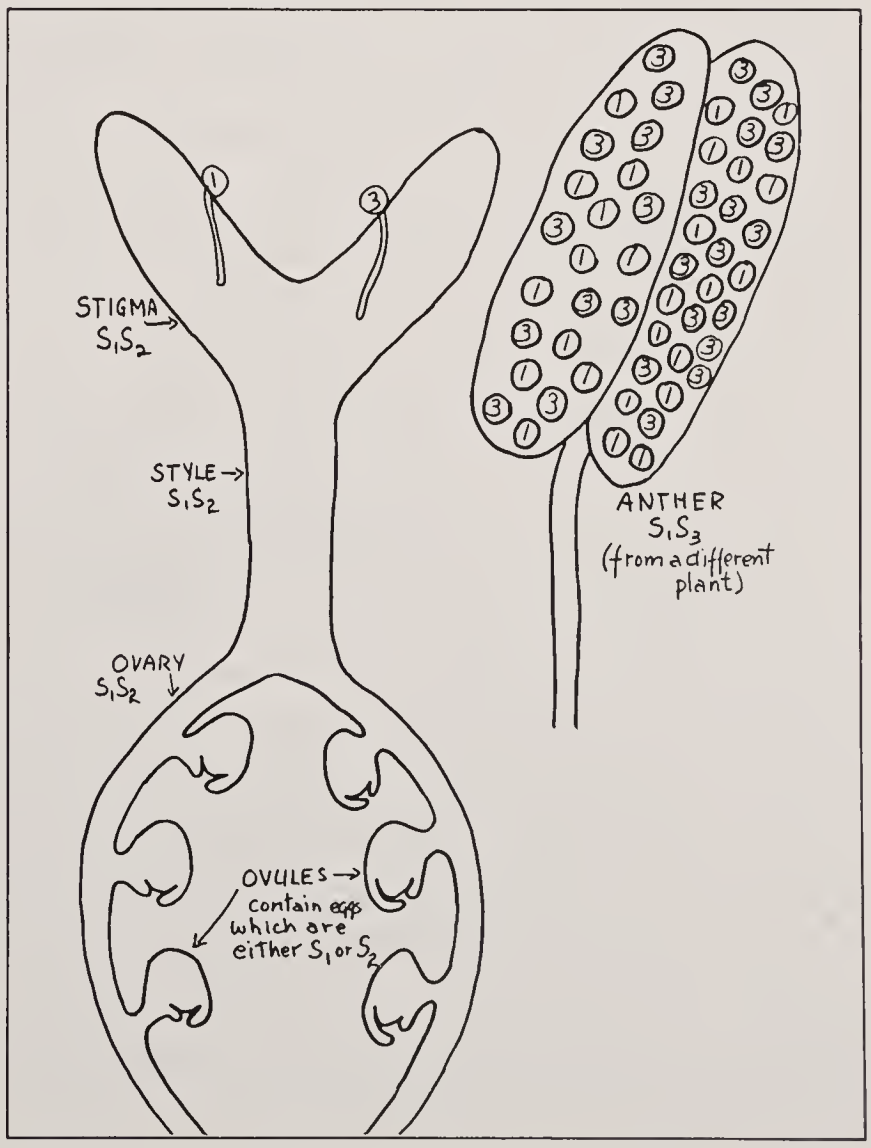
Figure 3. Diagram shows the pistil of a self-incompatible plant of genetic constitution S_1S_2, and an anther from another plant, genetic constitution of which is S_1S_3. Incompatibility in this case is under gametophytic control, and, hence, as shown, growth of only the number 1 pollen grains is inhibited. Only after the pollen grains were fully developed gametophytes did their incompatibility substances develop, and therefore the number 3 grains were not affected by substances from the sporophyte nor from the number 1 grains. As shown, the pollen tubes from the number 3 grains are uninhibited, grow all the way to the ovules, which can then be fertilized to produce seeds.

of one of the chromosome pairs. These are called S-alleles or S-genes. When this plant produces pollen, the chromosome number is halved, and hence each pollen grain gets one or the other of these S-genes, either, for example S_1 or S_2, but not both. A plant which produces both S_1 and S_2 types of pollen grains will have both S_1 and S_2 genes in stigmatic and stylar tissues. The growth of pollen tubes from pollen grains that are deposited upon a stigma containing the same S gene is inhibited at some stage of their development, they fail to fertilize the ovules and hence fail to produce seeds. Pollen grains which have S genes different from that present in the stigmas and styles produce tubes that rapidly penetrate these tissues, reach the ovules and produce seeds. Figure 1 is a diagram that illustrates the inhibited growth of pollen tubes produced by pollen from an S_1S_2 plant on its own stigma, and the uninhibited growth of pollen tubes from an S_3S_4 plant into the stigma and style of the S_1S_2 plant. Figure 2 illustrates comparable behavior of S_1, S_2, S_3 and S_4 pollen of S_3S_4 stigma/styles.

Some other pairs of plants differ, of course, by only one of these genes, having the other one in common. What occurs, for example, if an S_1S_2 plant is pollinated by an S_1S_3 plant? In some species (Fig. 3) half of the pollen will function under these circumstances, whereas in other species (Fig. 4) none of the pollen from the S_1S_3 plant will function to produce seeds in the S_1S_2 plant. In view of these differences, two major genetic systems of self-incompatibility, *gametophytic* and *sporophytic*, came to be recognized, and have been found to account satisfactorily for most of self-incompatibility phenomena in the flowering plants.

A review of some elementary botany is now necessary in order to complete this explanation; most plants (unlike *all* animals) have two alternating generations, designated as the sporophyte and the gametophyte generations. Sporophytes (the obvious "plant" of the species under discussion) have pairs of chromosomes. In the formation

Figure 4. Diagram shows the pistil of a self-incompatible plant of genetic constitution S_1S_2, and an anther from another plant, genetic constitution of which is S_1S_3. In this case incompatibility is under sporophytic control, and hence, as shown, growth of the number 3 pollen grains as well as that of the number 1 grains is inhibited. Apparently the S_1S_3 sporophyte generation incorporated both S_1 and S_3 substances into the walls of both the types of pollen grains produced by it.



of their spores, each chromosome pair separates, or is *reduced*, so that the resultant chromosome number is half that of the sporophyte. These spores are the first cells of the gametophyte generation. Some of these spores (often considered as male) are formed in the anther portion of the stamens and grow into pollen grains and pollen tubes, which may be considered as the male gametophytes. Others (female) are formed in the ovary portion of the pistils and grow into the female gametophytes which are called "embryo-sacs". The incompatibility reaction, as you will recall, is an interaction between the male gametophyte (pollen tube) and the tissues of the sporophyte generation (stigma and style). What is apparently crucial in distinguishing the two basic systems of self-incompatibility, gametophytic versus sporophytic self-incompatibility, is the timing in the development of the pollen when the incompatibility genes produce their incompatibility substances. If these substances are produced after the chromosome number has been reduced it is only the gene in each pollen grain that is effective, and this type of incompatibility is designated as gametophytic. On the other hand, if the genes begin to produce their substances before chromosome reduction has occurred, and the tissues are still sporophytic, the pollen grains get substances from both of the genes of the sporophyte even though the grains themselves are gametophytes. Under these latter circumstances, therefore, incompatibility is said to be sporophytic. In Figure 3 the behavior of two gametophytically self-incompatible plants differing by only one S gene is illustrated, whereas that of two sporophytically self-incompatible plants differing by only one S gene is shown in Figure 4. Thus, even though the two plants differ by only one S gene, they are fully self-incompatible when under sporophytic control; under gametophytic control the two plants are only half incompatible.

An explanation for the difference in the behavior of these two types of self-incompatible plants has been sought by studying any differences in the development of the pollen grains. Recent research has shown that substances that are active in the incompatibility reaction of plants exhibiting sporophytic self-incompatibility are present in the outer layer of the pollen grains, and further that this layer is deposited on the developing pollen grains from substances of sporophytic origin from cells lining the inside of the anthers. There is also evidence, although it is yet not as conclusive as that concerning the substances in the outer layer of pollen from sporophytic self-incompatible plants, that it is an inner layer of the pollen grains of gametophytic self-incompatible species that is active in the incompatibility reaction of these plants. This layer is known to be formed after separation of the two S genes, and only one or the other can then be present in each pollen grain; the substance then would be produced by action of only one of the S genes.

Environmental circumstances have been found to ameliorate the effectiveness of genetic self-incompatibility for some species. In self-incompatible tobacco, for example, self pollinations near the end of the growing season sometimes produce some seeds, and at other times seeds have been produced by pollinating the stigmas of mechanically-opened young buds. In some other self-incompatible plants the genetic effects are so strong that neither of these procedures have been effective toward counteracting incompatibility. Some species of the evening primrose (*Oenothera rhombipetala, O. caespitosa* and *O. organensis*), which my students and I have studied, have this high degree of incompatibility, yet we have found that we can reduce the strength of the incompatibility as measured by the extent of growth of pollen tubes into otherwise incompatible stigmas and styles by first immersing the stigma-styles into warm water. Approximately 50° (122°F) for 5 minutes has proved the most effective for *O. organensis*. Pollen grains that otherwise would grow tubes barely longer than a fraction of a millimeter grow well into the otherwise incompatible stigmas and at least part of the way through the styles following this treatment. This 50°C warm water treatment has proved effective in other plants, but with slight differences in the time required. In some lilies, for example, where the stylar tissues are thicker than in *O. organensis*, six minutes is required, whereas in *O. rhombipetala* which has styles even thinner than those of *O. organensis*, an approximate 2½-minute treatment proved most effective.

We do not yet know why these heat treatments are effective, but our best guess is that incompatibility is caused by an interaction of protein substances of the stigmatic-stylar tissues and those of the pollen tubes, and that a breakdown of the proteins occurs at approximately 50°C. We do know that 45°C is ineffective, and temperatures

much above 50°C kill the cells, resulting in no growth at all of any pollen tubes.

Treatment with X rays and even with ultraviolet light also leads to a decrease in the strength of incompatibility, but as yet neither these radiation exposures nor the warm water treatments have been applied in any practical way toward counteracting incompatibility in commercial crop plants. Selection of mutations to self-compatibility probably offers a better means for practical control.

REFERENCE

De Nettancourt, D. 1977. Incompatibility in Angiosperms. Springer-Verlag, Berlin, Heidelberg, New York. 230 pp.

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Self-incompatibility, as described above by Professor Hecht, occurs in a number of plants popular in Northwest gardens. Prime examples are to be found in the genera Chrysanthemum, Lilium *(lilies),* Callicarpa *(beautyberry), and among many species of* Rhododendron. *Research has been carried out on most of these taxa as well as on the species of* Oenothera *which Professor Hecht has studied. The reader is referred to an article by Robert J. Campbell in the* American Rhododendron Society Quarterly Bulletin *(Vol. 30, No. 2, Spring 1976) for further information along these lines.*

The other side of the coin, of course, is the breakdown of species integrity by cross-pollination. Rhododendrons are again a case in point. Any one of us who has grown a package of open-pollinated seed from the ARS exchange knows that it will be a matter of sheer luck if the resulting seedlings are true to the seed parent.

And rhododendrons are not the only culprits. Chance hybridization among garden plants is the cause of more mislabeling and more disappointment for plant collectors than any other factor. It can, however, produce such superb, hardy plants as Mahonia *'Arthur Menzies', which was grown at the Arboretum from a packet of* M. lomariifolia *seeds sent by the Strybing Arboretum in 1961. It is thought that this rogue is a hybrid between the tender but very beautiful* M. lomariifolia *(the seed parent) and the much hardier* M. bealei.

In the following article, Professor B.J.D. Meeuse explores the species concept and the breakdown of species integrity in natural populations. As we have seen, the phenomena he describes are not confined to plants growing in the wild. The same principles may be applied as well to plants growing in our own gardens.

THE EDITOR

A Tour of New Zealand Autumn 1980

Fans of Joe Witt and those who have long wished to travel down under will be pleased to know that he is scheduled to lead a three-week tour of New Zealand next fall. The group, which is limited to 25, will see both native and exotic floras, visiting native habitats as well as outstanding gardens.

Further details will be available in the coming months. Call Ruth Jacobson (543-2730) to keep yourself informed.

Species Hybridization in Plants

*B.J.D. MEEUSE**

What is a plant species?

Plant breeders know that, generally speaking, when pollen from one plant species is put on the pistils of flowers of another species, normal seed-production will not occur. Obviously, there are biochemical barriers that guard against such hybridization, helping to maintain what we call "species integrity". Typically, pollen of a given species will germinate only on a flower of the same species (sometimes the same flower which produced the pollen, although nature generally frowns upon self-pollination). So impressive is this simple fact of life that many botanists, turning things around at the risk of circular reasoning, have used it to define what a plant species is: that is, a group or population of individuals which, under appropriate conditions, can and will interbreed freely, producing viable and fertile offspring. Put simply: if plant A and plant B cross easily, they belong to the same species; if they do not cross, they do not.

Difficulties with the species concept

A fine definition—but alas, there are vipers in the grass! For instance, for many years, commercial orchid growers have skillfully exploited the knowledge that in the orchid family there are many plants which, though belonging to different species (or even genera!) if judged by yardsticks such as shape, size, color and construction, nevertheless can be crossed with the greatest of ease by artificial techniques. Indeed, most orchids sold for corsages and floral arrangements come from hybrid plants, the offspring resulting from *crosses made between species*!

In the field, orchid hybrids are rare, sometimes exceedingly so. There, species integrity is maintained quite successfully. But how is it done in the proven absence of chemical barriers? Related to this question are two others: how, in the process of evolution, can two or more species arise from a single ancestral species, and what mechanisms are active in the process of speciation? Of course the problem is by no means confined to the Orchidaceae, but this group lends itself very well to such questions because it may well be the family with the largest number of species. Among the flowering plants, about one species in ten is an orchid, giving a total of 25,000 to 30,000. Speciation has been especially vigorous here, but at the same time, the maintenance of species integrity must have been quite successful.

General isolating mechanisms

At first glance, it might seem that geographical isolation is a most powerful factor in maintaining species integrity—and we concede that very often it is. If two species are never found together in the same landscape, their chance of producing hybrids is obviously nil. Problems do not arise until man—that nefarious animal—disturbs the natural scheme of things by activities such as road building, thereby bringing together species which normally would never encounter one another. However, even then "crossable" species may be kept from hybridizing if they flower at different times of the year; or if, even when they bloom at the same season, their flowers are open and receptive to pollen at different hours of the day. The really tough task facing the botanist is to explain why there may be no appreciable production of hybrids in environments such as mountain meadows and tropical jungles where, for example, one often can find several species of orchids not only growing near each other but also flowering lustily in the same season and at the same time of day.

Pollinator specificity as a factor in maintaining species integrity

To find the answer it is illuminating to consider

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the case of *Ophrys*, orchids mentioned in R. del Moral's article on plant mimicry in the *Arboretum Bulletin* (Vol. 42, No. 1, Spring 1979). In this case, pollination is quite specific; male wasps or bees try to mate with the flowers which resemble their females in appearance and odor. This is called *pseudocopulation*. No other insects are able to extract the pollinia (pollen packages); furthermore the male pollinators, interested solely in sex, tend to go only from *Ophrys* to *Ophrys*. Therefore, the chance of hybridization with other orchids is almost zero. The barriers safeguarding species integrity in this case can be said to be ecological or behavioral.

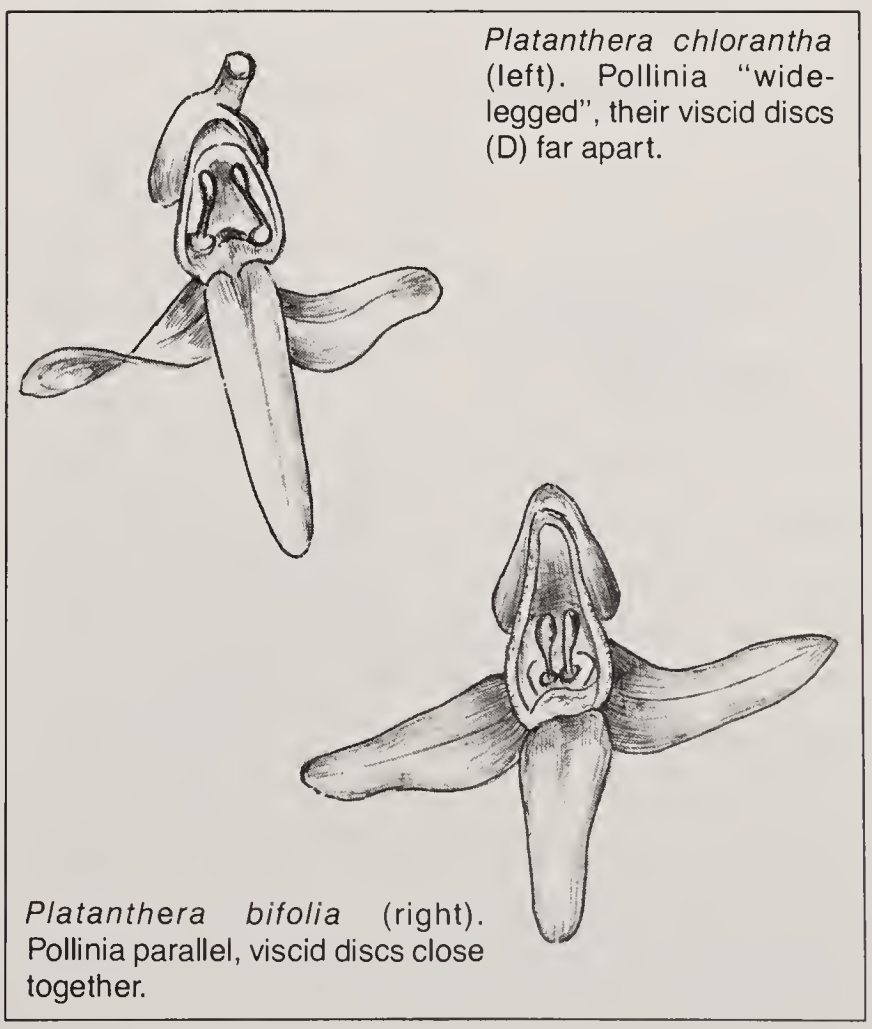
Mechanical barriers

In many other orchids, such barriers are more subtle but no less effective. Often they are structural. A case in point is that of the two Eurasian/Mediterranean orchids *Platanthera chlorantha* and *P. bifolia* which even experts find difficult to distinguish, while at the same time their areas of distribution are practically identical, at least in Europe and North Africa. In his delightful book on orchids published in 1862, Charles Darwin boldly postulated that the two are indeed separate species. He suffered some ridicule for this hypothesis, since the only consistent difference he was able to identify was the angle of divergence between the pollinia, which indicates the distance between the so-called viscid discs (Fig. 1). There were many who considered this difference too insignificant to be the basis for a species distinction, but their ridicule was misguided. The viscid discs play such a crucial role in pollination of these orchids that any significant change in their position is bound to be reflected in a change of the whole pollination system—a fact which Darwin recognized much more clearly than most botanists of his time. No pollination can result when an insect takes pollinia from the flowers of *P. bifolia* to those of *P. chlorantha* and vice versa. Since there can be no exchange of genetic material between them, these species will go through the process of evolution as separate entities, and the chances are that in the future they will become more and more dissimilar. What we have before us now is a case of beginning or incipient speciation. The difference, seemingly so slight but with far-reaching implications, must have occurred through a mutation or a series of them.

Animals as agents that select against hybrid forms

One might take the position that in the case of our two *Platantheras* the role of animals was secondary, since the course of evolution was changed decisively as soon as the relevant mutations had occurred in the ancestral plants. The role of pollinating animals is much more obvious in a classic case described by Verne Grant (Grant, 1952). It concerns two species of columbine: the well-known *Aquilegia formosa*, so common in our state of Washington, whose orange-red and yellow flowers are pollinated (mostly) by hummingbirds, and *A. pubescens* which has whitish flowers pollinated (mostly) by hawkmoths (Figs. 2 and 3). Additional differences besides color occur in the length of the nectar spurs and the position of the flowers. Although the two species usually grow in different habitats, they occasionally occur together. Grant noticed that in one such case fertile hybrids were formed, probably through the action of bumblebees, which did not discriminate between species in this case. The hybrids, more or less intermediate in appearance and structure between the two parental species, then became the objects of a selection process exerted by the pollinators. It is plausible that hawkmoths will tend to visit the hybrids and *A. pubescens*, producing offspring which are closer genetically to the latter

Figure 1. Comparison of flowers of the orchids *Platanthera bifolia* and *P. chlorantha*. The different position of pollinia and viscid discs has a decisive effect on pollination, preventing hybridization. Drawing: B.J.D. Meeuse.



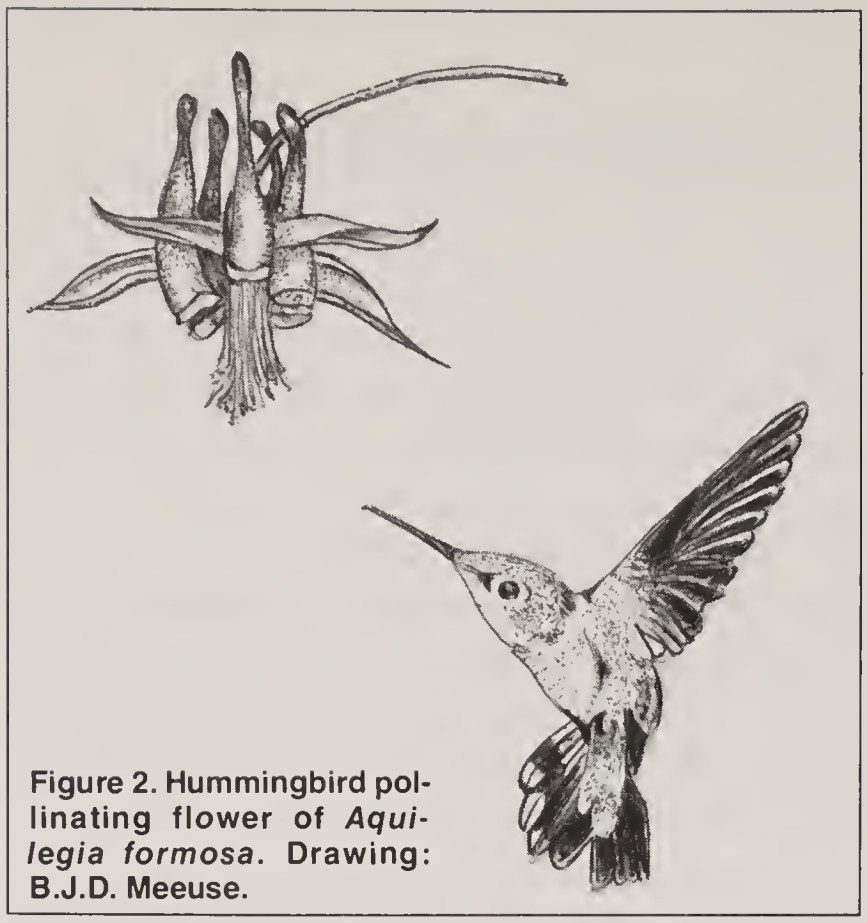


Figure 2. Hummingbird pollinating flower of *Aquilegia formosa*. Drawing: B.J.D. Meeuse.

than the original hybrid was, while by the same token hummingbirds will visit the hybrids and *A. formosa*, thereby producing offspring that approach the latter in their genetic make-up and appearance. Thus, in the course of time, the hybrid swarm will differentiate into two groups, one composed of plants closely resembling *A. formosa* and the other with individuals very similar to *A. pubescens*. One can say that the genetic factors or genes present in *A. formosa* and *A. pubescens*, which were lumped together when the original hybrids arose, will be sorted out again by the pollinators! According to Grant, this is indeed what happened.

The role of soil factors

It is true that his conclusions have been assailed by various investigators; for example, Chase and Raven reported in 1975 that, in the same locality studied by Grant, species integrity was maintained in spite of the fact that the pollinating animals (bumblebees and hummingbirds) did not discriminate greatly between the two species. If their observations are correct, this would mean that the pollination systems are not solely responsible for maintaining species integrity or for the failure to do so. An important factor may, for example, be the varying ability of parental species as well as hybrids to cope with particular soil conditions, which may differ considerably from one location to the next; those types unable to maintain themselves in a given habitat are simply "weeded out" in the course of time.

In this context, it is instructive to consider the case of the hybrids between two widespread and distinct species of *Ceanothus*—the coastal *C. gloriosus* and the interior *C. cuneatus*—which have arisen in three areas of central California (a geologically complex region). The hybrid populations are fairly variable but are nevertheless "stabilized", each representing a recognizable new entity. Presumably, they grow better than either parent in those areas where they occur; in the course of time, it was the hybrids rather than the parental species that were favored by natural selection! Soil factors must have been decisive.

Additional factors working for or against species isolation

Returning to situations such as those described by Grant, a great deal depends also on the botanical make-up of the area. If, for instance, *Aquilegia formosa* is relatively rare in comparison with *A. pubescens*, hummingbirds (which are, after all, very versatile pollinators) may well pay frequent visits to the latter species, in spite of the fact that they are not very well adapted to it. Such behavior will be especially pronounced when other flowers to which they are better adapted are rare or not blooming at that time. It must be clear that under such conditions Grant's *Aquilegia* model breaks down. However, he is not blind to this (Grant, 1976), and the fact remains that he has put his finger on an important principle. Furthermore, at this stage of the game it seems somewhat myopic to restrict the discussion to *Aquilegia*, since for other plants such as *Pedicularis* and *Salvia* situations have been described which lend themselves very well to Grant's model (Sprague, 1962, and Epling, 1947).

A further instructive case, described by Richard Straw of California State University in Los Angeles, is that of *Penstemon spectabilis*, found in the mountains of southern California and usually described as a species. There is good evidence that in reality it is a hybrid between the very dissimilar species *P. centranthifolius*, which has slender, tubular red flowers, pollinated by hummingbirds, and *P. grinnellii*, which has broad, two-lipped flowers, a very pale blue in color and pollinated by large bees such as carpenter bees. The flowers of *P. spectabilis* are intermediate and have a rose-purple color. They have found their own specific pollinators—wasps belonging to the genus *Pseudomasaris*, which are behaviorally

atypical, as wasps go, since they are pollen collectors. Since neither *P. centranthifolius* nor *P. grinnellii* is visited by *Pseudomasaris*, there is no mixing of genetic material between *P. spectabilis* and either parent. Considering the hybrid to be a new species is therefore entirely correct: it will maintain its integrity and separate identity and will follow its own evolutionary path, uncontaminated.

Floral constancy and a case of "leaky" barriers

The above examples deal with cases where the pollinators are totally different from one another and are strictly adapted to different flower types. However, plant species integrity often can be maintained even when the pollinators are very closely related, for instance when they are all bumblebees. Extremely important in this context is the phenomenon of floral (flower) constancy displayed by both honeybees and bumblebees. It is based (1) on the ability of the pollinators to distinguish between the color- and smell-signals produced by *different* flower species (that is, to "recognize" each flower species), and (2) upon the tendency of individual pollinators to forage for a period of time (which may well extend to several weeks!) on a single species even though other food-plant species are present. In other words, the pollinators behave, at least for a period of time, as strict specialists!

Flower constancy looms large in a beautiful analysis of the relative importance of hybridization versus maintenance of species integrity, carried out by Manja Kwak in the Netherlands. Two species of *Rhinanthus*, *R. minor*, the yellow rattle, and *R. serotinus*, the greater yellow rattle, are found in the same habitat blooming roughly at the same time of year, and are separated by "leaky" isolating barriers. Both species are visited by 11 species of bumblebees, and these form a very heterogeneous group, displaying differences in tongue length, body size, caste (since workers as well as queens are represented), the degree of floral constancy, and, finally, the manner in which the insects work the flowers. Thus, in so-called sternotribic pollination it is the ventral side (the belly) of the visitor that contacts the stamens and/or stigma, whereas in nototribic pollination it is the dorsal side (the back) of the visitor that receives and carries the pollen. A bumblebee could bring about hybridization by visiting flowers of both plant species during one foraging trip and consistently using one method of entering (either sternotribically or nototribically). Plant species integrity (reproductive isolation) would be maintained if the insect visited only one species per foraging trip, or if it visited both species but always behaved nototribically toward one and sternotribically toward the other. There could also be partial isolation between the two *Rhinanthus* species in those cases where bumblebees with short or medium-sized tongues visited both plant species during one foraging trip.

The stigma of *Rhinanthus minor* is not very accessible, and might not always be able to touch those parts of the bumblebees' bodies where pollen of *R. serotinus* has been deposited; consequently, *R. minor* remains relatively pure. The reverse situation would lead to hybridization, since the stigma of *R. serotinus* is not inaccessible and is therefore quite capable of picking up *R. minor* pollen from those parts of the visitors' bodies that carry it.

In three successive days of observation in the field, Kwak found that about 40 percent of the foraging bumblebees restricted their visits to one *Rhinanthus* species (thus helping to maintain species integrity) while roughly 60 percent visited both. Three short-tongued bumblebee species turned out to be good hybridizers, while one species with a medium-sized tongue was responsible for partial isolation (namely, isolation of *R. minor* with its relatively inaccessible stigma). Figure 4 illustrates the situations we have just described.

It must be clear that, in *Rhinanthus*, species integrity or the lack of it depends on the particular array of bumblebee species present in the land-

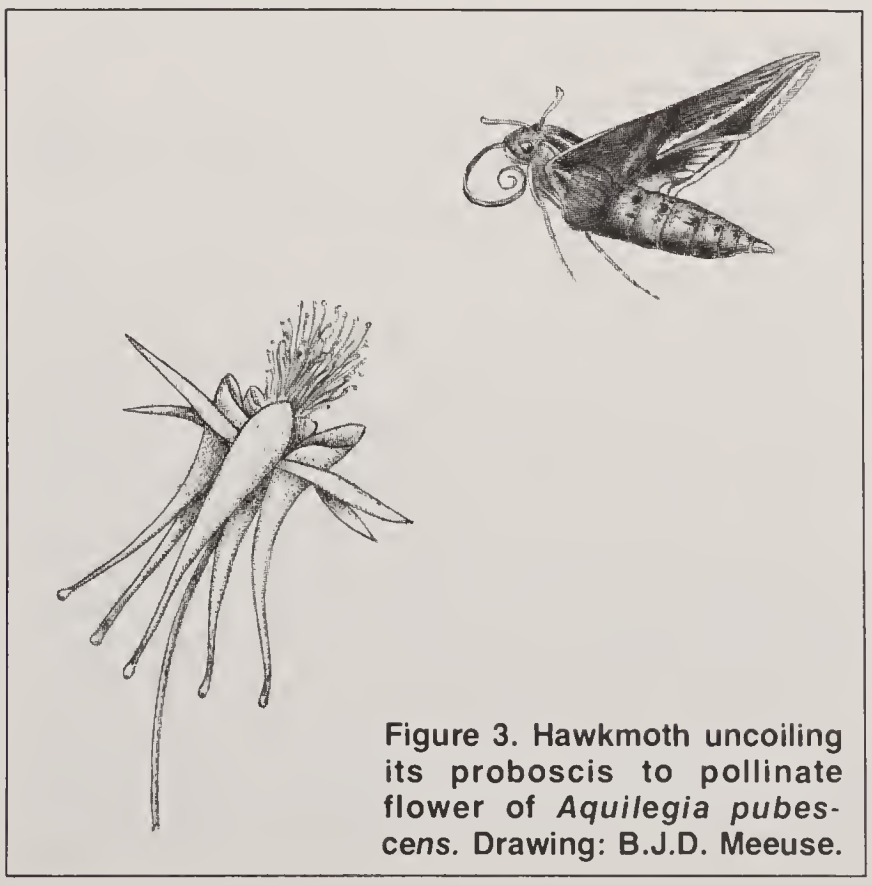
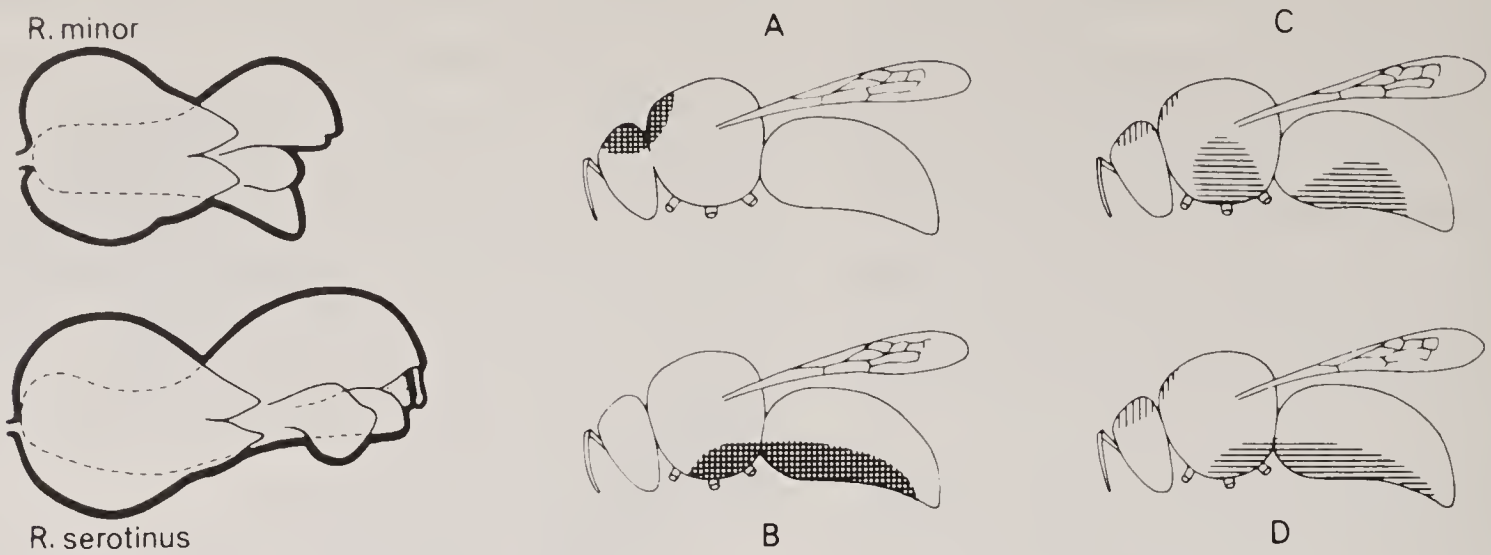


Figure 3. Hawkmoth uncoiling its proboscis to pollinate flower of *Aquilegia pubescens*. Drawing: B.J.D. Meeuse.



pollen R. minor pollen R. serotinus pollen both Rhinanthus species

"A" shows the situation for those bumblebee species which enter *Rhinanthus* flowers in such a way that they will always receive the pollen on the back (nototribic pollination), while "B" presents it for those species which will always receive it on the belly (sternotribic pollination). When visiting both *Rhinanthus* species in one foraging trip, bees in either category (A or B) will cause hybridization.

"C" represents those bumblebees (workers of *Bombus pascuorum*) which in *Rhinanthus minor* receive pollen on the back, while in *R. serotinus* they enter the flowers in an "oblique normal" fashion. Visits of such individuals to both *Rhinanthus* species during one foraging trip lead to only partial hybridization, because of the relative inaccessibility of the *R. minor* stigma.

"D" represents those short-tongued bumblebees which in *Rhinanthus minor* receive pollen on the back, while in *R. serotinus* they receive it on the belly. Animals in this group will fail to cause hybridization even if they visit both plant species during one foraging trip.

Figure 4. Relationships between pollinating bumblebees and two species of yellow rattle *(Rhinanthus)* in the Netherlands, according to M. Kwak (1978).

scape and on their relative abundance. Since the different bumblebee species do not all have the same vulnerability toward bad weather, it must also be clear that the picture may change from one year to the next. Furthermore, there is evidence that, once a hybrid swarm has been produced, the situation will be similar to that which Verne Grant observed in his two *Aquilegia* species. The long-tongued bumblebee, *Bombus hortorum*, shows a strong preference for the flowers of *R. serotinus*. It is quite likely that it, as well as some other bumblebee species, will alternate between the flowers of *R. serotinus* and those of the hybrid forms. So, again we may assume that the hybrids are subjected to a strong selective pressure exerted by the pollinators.

Apomixis

It is plausible to assume that in general the evolutionary success of hybrid populations depends to a large extent on their fertility. However, even if hybrids are sterile or nearly so, they are not necessarily doomed to extinction: they may reproduce themselves by a variety of vegetative means. The success of vegetative reproduction is demonstrated by many of our weeds. The dandelions of our lawns, for example, use a method known as *apomixis*: in their flowers, the ovules (the precursors of seeds) will develop into viable seeds without being fertilized! (One can easily convince oneself of this: cutting off the entire upper part of a dandelion flower head does not interfere with seed production!). The offspring of course will be very much like the mother plant. Indeed, within a relatively small area, weed populations tend to be quite uniform genetically. If a given type is very well adapted to its particular environment, disaster would befall the species only if the environment were to change drastically. That danger, of course, is not totally imaginary. From the evolutionary point of view, an apomictic system will benefit if new apomictic types (with a different, perhaps more favorable, genetic make-up) are occasionally produced by hybridization.

One of the best examples of such a system is found in Kentucky bluegrass (*Poa pratensis*), an extremely variable species common in both Eurasia and North America. Occasionally, bluegrass will produce hybrids with other grasses (a whole series of related species can provide partners!), and the result is hundreds of apomictic races, each well adapted to the ecological characteristics of its region. Hybridization, of course, does not automatically lead to such superior types; only the best combinations are maintained

in a given area by natural selection. Whether the well-adapted individuals reproduce sexually or not makes no difference in this kind of system, because their success does not depend on sexual reproduction. In extreme environments where insect pollination is difficult, for example in the arctic and in the high-alpine, apomictically reproducing individuals may be quite successful. A population of sexually reproducing plants would contain much more genetic variation, but many of the individuals, representing less well-adapted types, would be "weeded out" by the harsh environment.

Epilogue

Whole library shelves can be filled with books and articles dealing with species integrity, hybridization and speciation; our list of references presents just a few of them. In the above discussion, we have merely scratched the surface, omitting many factors and principles that might be involved. Also, my dear readers, there is a chance that I have left you thoroughly confused. We started this article with a definition of plant species which essentially we have demolished! In a number of cases, it is clearly impossible to define plant species without bringing in such extraneous agents as the animals that pollinated them. Perhaps it is fair to say that no one *really* can come up with a good definition of plant species; but at least this will keep us botanists humble, a situation from which the citizenry-at-large can only profit.

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Book Review

BUMBLEBEE ECONOMICS, by Bernd Heinrich. Harvard University Press, Cambridge, Mass. and London, England, 1979. 245 pp. Price $17.50.

Bumblebees are among our most important pollinators. This was made clear in a humorous way more than a century ago by Thomas Huxley, friend of Charles Darwin and staunch defender of his theories on evolution. Huxley's assertion was that in the final analysis the greatness of the British Empire depended upon England's spinsters. His line of reasoning was roughly as follows: spinsters tend to keep cats; cats keep down the population of field mice, animals known to destroy bumblebee nests; more cats means fewer mice, more bumblebees, and better pollination of clover; consequently, there will be more food for cattle and, finally, more of the red meat used for feeding Her Majesty's soldiers and sailors!

This is a delightful exaggeration, but one should remember that in the United States bumblebees are worth billions of dollars to farmers for clover pollination alone. In contrast to honeybees, whose origin must have been tropical or subtropical, bumblebees are so well adapted to cold climates that one can observe their activity even in places such as Lake Hazen in the high arctic and the high-elevation mountain meadows of Mount Rainier. Unlike honeybees, bumblebees remain active at temperatures only slightly above freezing, because they possess special physiological mechanisms which essentially can turn them into warm-blooded animals. This means that their workday extends literally from dawn to dusk. No banker's hours for bumblebees!

Many species of flowers can be pollinated only by bumblebees, for example, shooting star, foxglove and monkshood (for the latter, see my article, "Bribes, de-

coys and ant guards", in the *Arboretum Bulletin*, Vol. 40, No. 1). Among their favorites are members of the heather family. Given the importance of this group to Northwest gardeners (rhododendrons, blueberries, cranberries), a review of Bernd Heinrich's recently published book on bumblebees is altogether justified.

Heinrich's glorious treatise should be on the bookshelf of every biologist, gardener and nature lover. Its author, Professor of Entomological Sciences at the University of California at Berkeley, grew up on a farm in central Maine, where he spent a great deal of time out of doors. He began to watch bees and bumblebees when still a very young boy, and his interest in these animals became an abiding one. Now a full-fledged zoologist with an unusual ability to design and carry through truly original experiments, Heinrich already has to his credit an impressive string of first-rate articles on his beloved insects. His present book incorporates previous results but goes far beyond them. However, instead of the smell of midnight oil, it has a delightful freshness and originality and an engaging style. Though sometimes a little tongue-in-cheek, it is always responsible and completely scientific. It should appeal to amateurs and professionals alike.

Its appearance at this juncture could not possibly be more timely. The central themes are energy, cost/benefit relationships, and economics (which is tightly interwoven in human societies with strategies and politics). There are only two sources of energy (food) available to bees—nectar and pollen. In the case of nectar, the amounts harvested by the foraging bees, as well as the caloric value of the food, can be measured accurately and a comparison can then be made between the energy the insect must expend to get the food, and the number of calories it harvests. At low temperatures, a great deal of energy must, of course, be invested in the initial warm-up before the foraging animal can even begin its activities. In early spring, a bumblebee queen incubating her brood has to expend a great deal of energy to maintain a temperature that will permit proper development of the eggs and larvae. It is in these areas particularly that Heinrich has done much of his brilliant experimental work.

However, he also pays attention to the energy situation and economics *at the colony level*, and there things are equally fascinating. He notes a fundamental difference between honeybees and bumblebees in the way they exploit their environment. One does not stretch the truth too far when one compares a honeybee hive with a socialist state (even though there is a queen!) or with a large corporation. There is an excellent communication system in this communal society. A scout honeybee returning from a rich nectar source will indicate the direction, distance and richness of that source to her hive mates by means of the bee dance made so famous by von Frisch. The same food source—one flower species at that location—will then be exploited by a large number of bees.

In stark contrast, bumblebees (as far as we know) have no communication methods comparable to those of honeybees. Their total enterprise, as Heinrich points out, can be compared to a cottage industry, for they forage as rugged individualists. The fact that individuals within one colony often differ markedly from one another in size is a biological advantage, because this means that a variety of flowers in the environment can and will be exploited. Bumblebees have been on this planet for at least 60 million years; obviously their system works. In fact, an unbiased observer must concede that their society is not markedly inferior to that of honeybees. There are various ways to skin a cat!

Many other thought-provoking situations are described in this excellent book. The vibrations of certain insects in their warm-up period must have infected the author, for it can indeed be said that this book is vibrant with life.

B.J.D. MEEUSE

Announcements from the Unit Council

From the profits of the 1979 Plant Sale, the Unit Council voted to give $20,000 to the Arboretum to be used at the discretion of the Curator.

Bulb Sale Chairmen, Jeanne Gardiner and Jane Rogers, report a preliminary gross profit from the 1979 Arboretum Foundation Bulb Sale of over $12,000. Perfect weather and countless volunteer hours contributed to the success.

Richard van Klaveren, Arboretum Propagator, will offer a GREENHOUSE MANAGEMENT SERIES: four 2-hour sessions in the Arboretum greenhouse, Wednesdays from 1 to 3 PM. Class limit is 17 (it was oversubscribed last year). Fee: $18.00. Call Arboretum Foundation office for reservations: 325-4510. Class dates and subjects will be:

February 6: Introduction, plant propagation technique, lab and greenhouse tour.

February 13: How plants grow, plant nutrition, flowering plant propagation.

February 20: Classifications and requirements for house plant propagation.

February 27: Plant diseases and problems.

The Education Committee will offer a WINTER LECTURE SERIES at 10:30 AM in the McCurdy Room of the Museum of History and Industry. Fee: $8.00 for Foundation members, $10.00 for nonmembers. Call Arboretum Foundation office for reservations: 325-4510. Individual tickets may be purchased at the door if there is room. Programs and dates will be:

February 6: Joe Witt, Arboretum Curator, will speak on "The Cultivated Conifer."

February 13: Melinda Denton, Professor of Botany at the University of Washington, will

present an outstanding slide program on her recent trip to Siberia where she collected plants for research purposes.

March 5: Ola Edwards, Research Assistant in the College of Forest Resources at the University of Washington, will lecture on "Mt. Rainier, an Alpine Island and Its Vegetation."

March 12: The Mae Granston Rhododendron Study Group will offer a program on rhododendrons including history, demonstration of propagation, and slides of hybrids and species.

The THIRD ANNUAL HORTICULTURAL EXHIBIT, under the chairmanship of Margaret Lockett, will be held in the McCurdy Room of the Museum of History and Industry on Tuesday, March 25, from 1 to 8 PM, and Wednesday, March 26, from 10 AM to 3 PM. The exhibit will feature early spring blossoms and foliage from the gardens of unit members plus special exhibits, including bonsai and container gardens. It will be free and open to the public.

The ANNUAL ARBORETUM FOUNDATION PLANT SALE will be held on May 7 and 8, 1980. Chairman Carol Hansen is hard at work getting her committees together. If you wish to volunteer, call her at 232-1546.

GUIDE TRAINING SESSIONS will be held for the Japanese Garden, native trail, school program and general tours on random Tuesdays from late January to early April. See the winter *Unit Quarterly News* for full details, or call Sheila Taft (523-5027), Elizabeth Moses (823-1746) or Vera Frazier (364-7066). The two-hour sessions, 10 AM to 12 Noon, include native plants, native trail, Foster Island, Indian plant uses, birds and water life. There is a $15 course fee for new guides, which includes learning materials. $10 will be reimbursed at completion of training and guiding requirements.

Tours may be scheduled through the following chairmen: General Guides, Margie Stevenson (232-3289); Native Guides, Virginia Level (363-8073); Japanese Garden, Janice Rabkin (323-2590).

Sally Sue Coleman will act as Unit Council Chairman of the SECOND HORTICULTURAL AF-FAIR scheduled for May. *MOLLY WOLFE*

In Memory of Mark Collarino

Mark Collarino, a native of Brooklyn, New York, spent his early youth in San Francisco, attending the University of California at Berkeley and later the University of California at Davis, where he graduated in Veterinary Medicine with a minor in Agriculture. His life work was in agriculture, serving in various administrative positions with the United Fruit Company from 1923 to 1965.

An outdoorsman, he gave much time to gardening, working especially with rhododendrons.

Mr. Collarino served on the Executive Committee of the Arboretum Foundation for many years, and was President from 1964 to 1966, during a period when many changes occurred. He was generous with his time and his talents—always encouraging, kind and thoughtful. It was a pleasure to serve as Foundation Secretary during those years.

MELBA SCHMITZ

New Members of the Arboretum Foundation

We are pleased to welcome the following new members (June 1, 1979 through August 31, 1979):
Sustaining—Mr. & Mrs. Thomas Steel. *Family*—Kendra Daly, Mrs. D.M. Duncan, Mrs. Andrew Price, Jr. *Annual*—Mrs. Nancy Bowen-Pope, Mrs. Joseph Carman, Laura E. Chandler, Judy Warren Clarke, Corps of Engineers, Mrs. Carol Currey, Mrs. Einar Frolen, H.T. Greer, Jr., Mrs. Norman Grossman, Herbert B. Hall, Mrs. John Harrington, Mrs. Dutton Hayward, Catherine Hovanic, Mrs. Sandra Medendorp, Jayne E. Monroe, Mrs. Archie Nowka, Mrs. MacMillan Pringle, Dr. J.C. Raulston, Jill S. Roseen, Mrs. Barbara Schick, Mrs. Mark Sias, Helen Smith, Mark P. Worcester, Phyllis Zimmerman.

University of Washington Classes

Spectrum, the quarterly journal for Continuing Education, is sent free to those who have indicated interest in the University of Washington's night courses, adult education classes, concerts and other programs. Those who wish to obtain early notice of such classes and registration forms are urged to place their names on the mailing list by calling 543-2590.

Continuing Education

ALPINE PLANT LIFE. Exploration of the flowering and other plants that grow above the tree line and the environments that sustain them, with emphasis on the Pacific Northwest flora. Instructor: Ola Edwards, Research Assistant, College of Forest Resources. Tuesdays, January 15-February 19; 7:30-9:30 PM; 6 sessions, $25.

SOILS FOR NORTHWEST LIVING. This course for lay persons will cover physical and chemical properties of soils, the processes responsible for their formation, soil-water interaction, soil-plant reactions, and soil-man relationships. Instructor: Fiorenzo Ugolini, Professor, College of Forest Resources. Thursdays, January 17-March 13; 7-9 PM; 9 sessions plus 1 field trip, $35.

SCIENTIFIC DRAWING. Instructor: Phyllis Wood, scientific illustrator, Health Sciences Illustration. Mondays, January 14-March 24; 7-10 PM; 10 sessions, $45.

Arboretum Courses

ORNAMENTAL TREES AND SHRUBS FOR THE GARDEN. Identification and effective use of 50 exotic and native ornamental shrubs and trees especially well adapted to Pacific Northwest gardens, large and small. Course will include information on plants for special uses, such as fall color, fragrance, drought and shade. Most class sessions will be conducted outdoors. Instructor: Pat (Duxler) Penfield. Class limited to 15; meet at Arboretum office. Saturdays, February 2-March 1; 1-3 PM; 5 sessions, $12.

BIRD IDENTIFICATION FOR BEGINNERS. Merilyn Hatheway, experienced birder, will conduct a field class on land birds commonly found in the Arboretum and waterfowl on Lake Washington. Binoculars required; appropriate clothing and boots recommended. Class limited to 15; meet at Arboretum office. Saturdays, January 12-February 23 (no class February 16); 9-11 AM; 6 sessions, $15.

GRAFTING ORNAMENTALS. Mr. Richard van Klaveren will instruct in techniques for grafting woody plants. Materials and plants furnished. Class limited to 15; meet at Arboretum greenhouse. Saturdays, February 9 & 23; 9:30 AM-12 Noon; 2 sessions, $15.

PRUNING ORNAMENTALS. Mr. Chico Narro will demonstrate techniques of pruning trees and shrubs. This is an outdoor demonstration class; appropriate clothing and waterproof footwear are recommended. Class is limited to 30; meet at Arboretum greenhouse. Saturdays, March 22 & 29; 2-4 PM; 2 sessions, $7.

TREE IDENTIFICATION. Common North American trees and many common and unusual exotic trees will be considered. Emphasis will be on the identification characteristics and natural distribution of the major species. Horticulture and tree ecology will also be discussed. Instructor: Carla Culver. Class limited to 20; meet at Arboretum office. Saturdays, February 23-March 22; 10 AM-12 Noon; 5 sessions, $12.

WINTER IDENTIFICATION OF NATIVE TREES AND SHRUBS. Course will cover 55 species of trees and shrubs native to western Washington, placing emphasis on distinctive identifying characteristics. Past and present uses of these plants in horticulture, medicine and by Native Americans will be discussed, as well as the habitats where the plants may be found. Instructor: Pat (Duxler) Penfield. Class limited to 20; meet at Arboretum office. Saturdays, February 2-March 1; 10 AM-12 Noon; 5 sessions, $12.

GARDENING. Mr. Chico Narro will instruct in basic gardening techniques and winter garden maintenance. Course will cover vegetable gardening and ornamentals; some time will be available for consultations on individual gardening problems. Class limited to 15; meet at Arboretum greenhouse. Saturdays, January 26-March 1; 2-4 PM; 6 sessions, $20.

Be sure to wear warm clothing and waterproof footgear for all courses that meet outdoors including the gardening course. PRE-REGISTRATION IS REQUIRED. For further information on Arboretum courses, call 543-2730.

Our readers are reminded that other classes and lectures are available in addition to those sponsored by the University. Some of the community colleges have active horticulture departments (see Peggy Farrell's article, "Horticulture Classes in Greater Seattle" in the *Arboretum Bulletin*, Vol. 41, No. 3, Fall 1978). The Northwest Ornamental Horticultural Society's (NOHS) program for spring 1980 is published in this issue. The Washington Native Plant Society (WNPS) has programs and field trips for its members. For information, contact Jan Dalby, 454-3477 (or Betty Jo Fitzgerald, 866-4607, for South Puget Sound).

Be sure to see UNIT COUNCIL ANNOUNCEMENTS for details of the classes and lectures offered for the public as well as members of the Arboretum Foundation.

CALENDAR OF EVENTS

Arboretum Foundation:	
Board of Directors	December 6
	March 13
Executive Committee	January 10
	February 14
Unit Council:	
Unit Council Meetings	March 20
	May 22
Governing Board	January 3
	February 7
	March 6

Regularly Scheduled:	
Greenhouse Day	Every Tuesday
The Mae Granston Rhododendron Study Group	1st Monday
Herbarium Committee	1st Friday
Northwest Natives Study Group	3rd Monday
Rock Garden Study Group	3rd Wednesday
Arboretum Explorers	4th Wednesday (including December 26)
Additional Walk	March 12

Unit Council
GREENHOUSE MANAGEMENT SERIES and WINTER LECTURE SERIES
(See page 40 for details)

NOHS lecture series: PLANTSCAPE 1980-2000 (See page 9 for details)

5TH ANNUAL PACIFIC NORTHWEST ROCK & ALPINE PLANT CONFERENCE
February 29-March 2, Empress Hotel, Victoria, B.C. (See page 9 for details)

3RD ANNUAL UNIT COUNCIL HORTICULTURAL EXHIBIT
McCurdy Room, Museum of History and Industry
Tuesday, March 25, 1-8 PM Wednesday, March 26, 10 AM-3 PM

ARBORETUM FOUNDATION PLANT SALE: May 7 and 8

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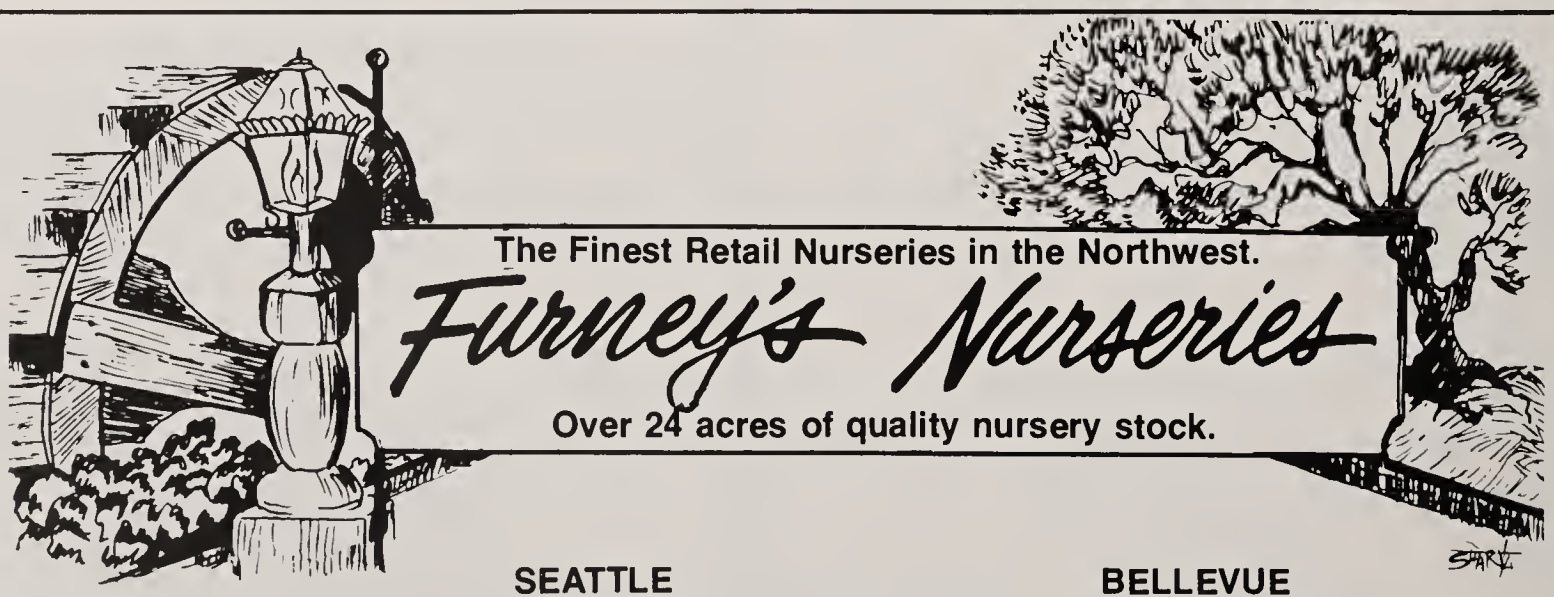

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***Mahonia* 'Arthur Menzies' covered with frost** **Photo: Joseph A. Witt**

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to help preserve the Arboretum's beauty and improve its facilities.

Join the Explorers' Walks meeting the fourth Wednesday each month in the parking lot of the administration building at 10 AM, December 26, January 23, February 27 and March 26. An extra walk is scheduled March 12.